ARMY RESEARCH LABORATORY

Reinventing Government Research and Development:

A Status Report on Management Initiatives and Reinvention Efforts at the Army Research Laboratory

by Edward A. Brown

ARL-SR-57

August 1998

A National Reinvention Laboratory &
Three-Time Hammer Award Winner

ARL Vision

A laboratory *preeminent* in key areas of science, engineering, and analysis relevant to land warfare.
A staff widely recognized as outstanding.
A laboratory seen by Army users as essential to their missions.
An intellectual crossroads for the technical commuity.

ARL Mission

Execute fundamental and applied research to provide the Army the key technologies and analytical support necessary to assure supremacy in future land warfare.

Army Research Laboratory
Adelphi, MD 20783-1197

ARL-SR-57 **August 1998**

Reinventing Government Research and Development:
A Status Report on Management Initiatives and Reinvention Efforts at the Army Research Laboratory

Edward A. Brown
Office of the Director

Abstract

The Army Research Laboratory (ARL) was activated at the beginning of fiscal year 1993. Since then, ARL has operated in an environment of continuing stress, caused by a variety of factors. Like many other "corporate" research laboratories, it has been subject to economic constraints and pressures, leading to downsizing, consolidation, infrastructure reduction, and outsourcing. As a military laboratory, it has also been significantly affected by the end of the Cold War.

To cope with this changing environment, ARL has undertaken a variety of management initiatives: in the current jargon, it has been reinventing itself. This report summarizes the current status of these ongoing initiatives. It begins with a discussion of the fundamental reinvention of the research effort at ARL—the Federated Laboratory—and then discusses several others that directly or indirectly support it. The report concludes with a summary appraisal, in "report card" form, of the reinvention efforts over the past five years.

Foreword

This report is, in some sense, the culmination of almost three decades of working towards the improvement in the management processes and techniques of Army/DOD research organizations in general, and of the Army Research Laboratory (ARL) and its predecessor, the Harry Diamond Laboratories (HDL) specifically. As such, the views and opinions expressed herein are strictly those of the author and do not in any way represent an official position of ARL, the Army, or the Department of Defense.

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1. Introduction and Background

The Army Research Laboratory (ARL) has undertaken a variety of management initiatives,* several beginning even before its activation almost five years ago. Some of these initiatives began under the auspices of programs such as the National Partnership for Reinventing Government (formerly the National Performance Review—NPR), some were in response to the Government Performance and Results Act of 1993 (GPRA), and some were inspired by the familiar need for cost-effectiveness in an era of tight budgets. Some of these initiatives have broken new ground in several areas of federal R&D management, such as partnering with the private sector, business planning, and performance evaluation.

This report is intended to assess what we have accomplished, where we have come from, and where we need to go next. This assessment is timely, since Congress is now turning its attention to this question. Congress wants to know what benefits (and in particular, what savings) have been derived from the NPR waivers program, whether Total Quality Management (TQM) has had any noticeable impact, whether GPRA is being implemented successfully, and so forth.

Parts of ARL's efforts have received outside recognition: During 1998, ARL received three of Vice President Al Gore's Hammer Awards from the NPR. Two of those awards were for initiatives discussed in this report: the Federated Laboratory and the Alternative Personnel Demonstration System. (The third Hammer was given in response to a customer's nomination for some exceptional service performed in a technical program.)

Even without the obvious encouragement of Congressional interest and other outside scrutiny, it is appropriate to pause after more than five years of effort for an assessment. This report looks at all our initiatives, puts them in perspective, provides a "warts and all" evaluation of our activities, and indicates where we need to go next.

The report begins with an evaluation of the Federated Laboratory (FedLab) initiative, the fundamental reinvention that ARL has undertaken. The rest of the report describes the other initiatives, which are either in direct support of FedLab or in general are efforts to improve the overall environment in which FedLab functions. These other initiatives include the "Open Laboratory," ARL's work as a National Reinvention Laboratory under the NPR, Business Process Reengineering (BPR), and our work in the Department of Defense (DoD) Laboratory Quality Improvement Program (LQIP), which includes our Alternative Personnel System Demonstration. Other efforts that have a more indirect relation to FedLab include our GPRA initiatives, benchmarking, and an in-depth investigation into the causes and control of overhead costs. These various reinvention initiatives can be viewed in terms of supporting the four principles of the NPR (table 1). The report concludes with a view of the application of TQM to a research organization.

**Descriptions of all the management initiatives discussed herein are linked to the ARL homepage at http://w3.arl.mil/mgtinit/.*

Table 1. NPR principles.

ARL initiatives	Cutting red tape	Putting customers first	Empowering employees	Cutting back to basics
Federated Laboratory (FedLab)	—	—	X	—
Open Laboratory	X	—	X	—
National Performance Review Reinvention Lab (waivers, including LQIP waivers)	X	—	X	—
Business Process Reengineering (BPR)	X	—	—	X
Alternative Personnel System Demonstration (Laboratory Quality Improvement Program, LQIP)	—	—	X	X
Government Performance and Results Act (GPRA) (business planning and performance evaulation)	—	—	—	X
Benchmarking	—	—	—	X
National Academy of Science/ Research Roundtable Overhead study	—	—	—	X
Quality programs (customer value, HEARTS,* PQA†)	—	X	—	—

**An experiential learning program (HEARTS = Honesty, Ethics, Accountability, Respect, Trust, and Support).*
†Presidential Quality Award.

1.1 ARL's History

ARL's genesis is found in seven formerly independent Army laboratories, one of which traced its ancestry as far back as 1816. These were as follows:

- Atmospheric Sciences Laboratory, White Sands Missile Range, NM
- Ballistics Research Laboratory, Aberdeen Proving Ground, MD
- Electronic Technology and Devices Laboratory, Ft. Monmouth, NJ
- Harry Diamond Laboratories, Adelphi, MD
- Human Engineering Laboratory, Aberdeen Proving Ground, MD
- Materials Research Laboratory, Watertown, MA
- Vulnerability Assessment Laboratory, White Sands Missile Range, NM

In addition, to these organizations, the Army Research Office (ARO) will become a part of ARL at the beginning of FY99. ARO, located in the Research Triangle area of North Carolina, is the Army's principal link to the academic basic research community. Through grants to universities, it supports a wide variety of fundamental investigations in areas of interest to

the Army. It is being combined with ARL to bring a greater synergy and mutual leveraging of the Army's in-house and out-of-house research programs.

When ARL was established, the fundamental research parts of a number of other Army organizations were also folded into the new organization. Though the genealogy is complex (see appendix), the current form of ARL is the result of a combination of events occurring in the 1987–1993 time frame. These included the Defense Management Review, conducted by the Office of the Secretary of Defense (OSD) in 1989–1990, which led to the Army's Lab 21 study in 1990, which recommended the establishment of an Army corporate research lab. Following these two studies there were several others, among them the Federal Commission on the Consolidation and Conversion of Defense Laboratories, the Base Realignment and Closure Commission (specifically, BRAC 88 and BRAC 91), and a study by the Board on Army Science and Technology (BAST) of the National Research Council. Based on the results of all these studies, the final form for ARL was determined, and in October of 1992 ARL was activated, with two main campuses at Adelphi and Aberdeen, an outdoor test facility at White Sands, an Atlanta site on the Georgia Tech campus, and two smaller detachments colocated with NASA laboratories at their Lewis and Langley Research Centers. The site at Watertown was closed, with its activities being relocated to the Aberdeen campus, and the presence at Ft. Monmouth moved to Adelphi.

ARL's charter dictated that it concentrate solely on basic and applied research (6.1 and 6.2 programs) and weapons analysis (6.6), giving up to other organizations all the development, engineering, and low-rate initial production work that had been done in several of its predecessor organizations. Its primary customers became the Research, Development and Engineering Centers (RDECs) of the commodity commands of the Army Materiel Command (AMC).

The objective of these various efforts was to improve the way fundamental research is performed in an Army environment. In an era of downsizing and budget cuts occurring simultaneously with a changing world situation and demands for an increasing future reliance on technology, it became obvious to the senior leadership that the Army's research enterprise needed to be streamlined and focused.

This arrangement is analogous to the industrial model of a central laboratory supporting the R&D centers in a large corporation's product divisions (fig. 1). Thus, ARL became the Army's "corporate laboratory."

1.2 Environment

The environment in which ARL operates has two salient features:

- extreme pressure on resources and
- heavy mission demands.

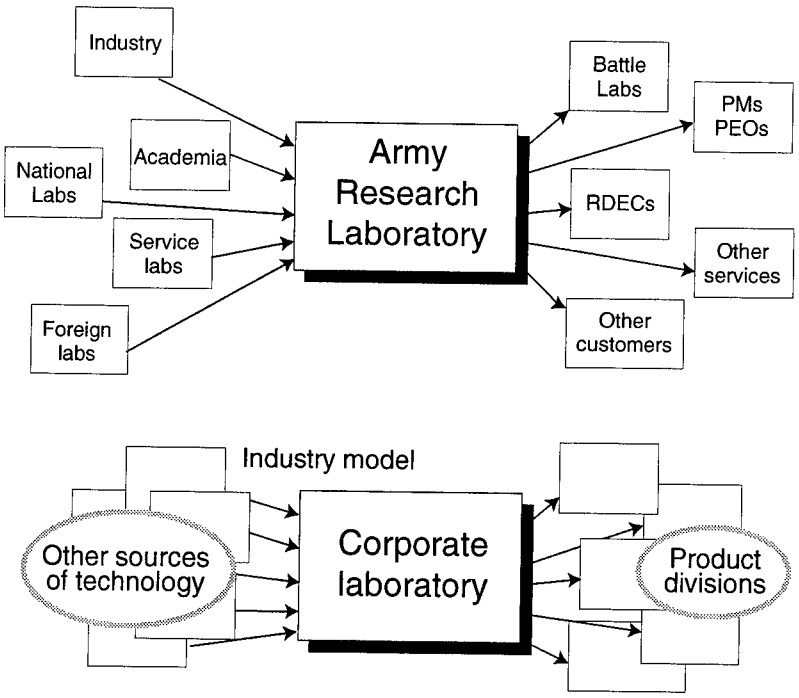


Figure 1. ARL's role is that of a corporate laboratory in industry: both to gather and to generate technology.

ARL is subject to the same kinds of pressures felt by its private sector cousins in the R&D community. When resources become scarce, long-term research becomes a target for cutting, since (by definition) its impact is not felt for many years. In general, R&D is difficult to defend: its products are difficult to measure, its outcomes cannot be quantified in advance, and results are often more serendipitous than predictable. Further, the two- or three-decade lag between investment and payoff means that leadership possessing extraordinary foresight is needed to defend against budget cuts when funding is tight.

As a research organization, ARL is susceptible to these kinds of pressure; as a military research organization, ARL is further susceptible to the changes that resulted from the end of the Cold War. Since the fall of the Berlin Wall, ARL (and its predecessor organizations) has been reduced 45 percent in personnel and 50 percent in funding (fig. 2), and the end of this drawdown is not yet in sight. Various external forces continue to press for even more closures, consolidations, and outsourcing of R&D, including pressures to increase cross-service integration of programs, to seek "dual use" solutions to materiel problems, and to use commercial specifications, standards, and products.

In the midst of these challenges, the Army's senior leadership gave ARL an entirely new mission. In response to the Desert Storm experience, General Gordon R. Sullivan, the previous Chief of Staff of the Army, directed that AMC proceed to develop the technology to "digitize the battlefield." In other words, AMC must devise systems that will enable real-time situational awareness for battlefield commanders at all levels. Such awareness demands wireless, near-instantaneous communication vertically and horizontally, with total fusion of all relevant information (intelligence, weather and terrain data, logistics information, etc), which must then be displayed in a readily comprehensible format. ARL was designated to develop the

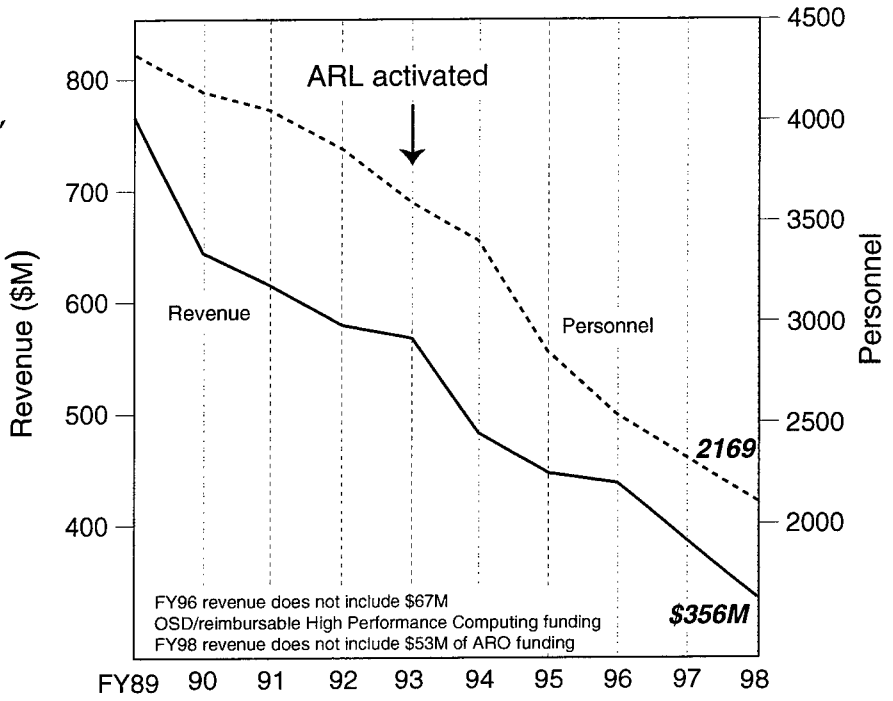


Figure 2. Decline in ARL's personnel and financial resources (before ARL activation, data reflect ARL's baseline determined from predecessor organizations).

scientific underpinning and hand off the necessary technology to the Communications and Electronics Command (CECOM) to design, build, and field the systems. ARL's current situation is thus a classic case of having to "do more with less."

1.3 Reinvention and R&D

These times of dramatic change require dramatic new ways of doing business. Both in the corporate world and in government, "reinvention" and "reengineering" are hot topics; books on these subjects have made it to the tops of various bestseller lists. Reinvention is all around: in the private sector, innumerable companies have "reinvented" themselves (sometimes with dramatic results), and in the federal government, the Vice President's National Partnership for Reinventing Government (NPR) initiative is aimed at reinvention. Increasing effectiveness and efficiency has become critical for survival.

The problem with such initiatives is that they risk becoming faddish; everyone jumps on the bandwagon whether it makes sense or not. Although the NPR office has documented many success stories, many claimed reinventions are only working at the margins. For example, reinventing the way your mail is delivered may be nice, but it does not contribute to the fundamental mission of your organization (unless you are the Postal Service). The joke about rearranging the deck chairs on the *Titanic* comes to mind (especially if an organization is in real danger of sinking).

In R&D it is especially difficult to find opportunities for substantive reinvention; R&D is simply too complex. While there is ample opportunity to reinvent the various support processes in an R&D organization, reinventing how the laboratory performs its fundamental mission is quite another story. This is the task ARL has set itself in devising the FedLab.

2. The Federated Laboratory: The Reinvention of R&D

The Federated Laboratory, or FedLab, is the fundamental reinvention of how ARL performs its mission. This concept of operations was instituted as a means to deal with the problem of conducting a new mission assignment at the same time that our resources were being reduced. The new mission—to develop the scientific underpinnings to digitize the future battlefield—presented multiple challenges: an important consideration was the existing exceptionally strong private sector competence (directed at civilian applications), which ARL could not, and indeed should not, try to compete with. Thus, ARL developed the concept of an intimate partnering with the leaders of the private sector efforts. In addition to allowing us to fulfill our mission responsibilities with a dramatically downsized staff, this approach has the advantage that it strongly leverages the commercial sector's large investment in expertise and facilities for the Army's benefit.

2.1 Background

When General Sullivan asked ARL to provide CECOM with the basic technology required to develop the future digitized battlefield, the ARL Director, Dr. John Lyons, inventoried his capabilities in this area. He found that although several researchers scattered throughout ARL were working in various technical areas relevant to the problem, the number was far from the critical mass of expertise required for this difficult technical problem. Moreover, it was evident that the private sector was far ahead of the military in developing and fielding wireless digital communications—as evidenced by the number of people walking around the streets with cellular phones held to their ears. Moreover, with new wireless devices appearing in the stores almost monthly, it was equally clear that the field was moving so fast that there was no possibility of starting up an effort from scratch and becoming a leader in the field. There was not enough money, people, or time to do that.

However, it also should be noted that there are fundamental differences between commercial and military technologies. For example, in the specific case of digitized communications, the commercial sector has the advantage of using fixed infrastructures in relatively benign environments. The military, on the other hand, must provide similar wireless communications plus all the other intelligence and data fusion tasks, in an environment of electronic jamming and hostile fire, for a customer that is the equivalent of a medium size city on the move. Thus, the approach to the digitized battlefield problem would have to bring the commercial and military perspectives together.

In light of all those considerations, ARL decided to move the existing technical elements within ARL into several focused groups and then go where the expertise already existed—the private sector.

Traditionally, this would have been accomplished through some sort of contractual process. This approach, however, has several major disadvantages: First, with contracts, which are "arms length" procurement vehicles,

ARL would not be able to specify the research objectives in advance and then modify them as the results emerge. Second, we would be unable to be active participants in the technical work. Rather, we would be able only to write scopes of work and issue contracts based on them, which then (if we were lucky) would yield technology that might be relevant to the extremely complex and sophisticated problems that the Army would face on tomorrow's battlefield. Such a process would not enable ARL to act as a "smart buyer" for the Army, since only a limited amount of in-depth technical knowledge would be available in house. What was needed was a new way to do our business—a reinvention.

The answer appeared in the form of a new authority granted to the DoD under 10USC2358: Cooperative Agreements (CAs, not to be confused with Cooperative R&D Agreements, or CRADAs, which are in no way related). The most important aspect of CAs is that they allow an intimate and substantial relationship between the government and the vendor. This meant that ARL would be able to form true partnerships with the private sector: to jointly plan and execute technical programs, jointly evaluate, assess, and report on the work accomplished, and redirect the work as necessary.

The potential offered by this new authority was immediately evident. ARL would be able to join with the private sector to produce the required technology and, in the process, expand the in-house team to allow the Army to efficiently integrate these new technologies into its acquisition system. Thus was born the Federated Laboratory concept of operation, FedLab.

2.2 What is FedLab?

FedLab can be thought of as a collection of geographically distributed, "virtual" laboratory divisions, augmenting the capabilities of the ARL directorates. These divisions work in the technical areas relevant to building a scientific foundation for the digital battlefield. FedLab involves integrating, under ARL leadership and direction, programs in the private sector with those already existing within ARL. Funding under the CA authority is provided by the government; this is not a cost-sharing arrangement. CAs are no-fee/no-profit arrangements.

The original design of the FedLab concept was envisioned as follows:

- Several different technology areas all related to the overall thrust of digitizing the battlefield were defined.
- For each area, a consortium would be formed to execute the program in partnership with ARL.
- A consortium would consist of *at least* one industry partner as the consortium lead, one major research university partner, and one Historically Black College or University or Minority Institution (HBCU/MI), which would receive at least 10 percent of the consortium's funding.
- Each consortium's activities would be directed by a Consortium Management Committee (CMC) formed by senior representatives of all the partners and chaired by a senior ARL technical manager as the Cooperative Agreement Manager (CAM).

- The duration of the CAs would be sufficiently long that the fruits of the basic and applied research could be realized.
- So as to enhance technology transfer between ARL and the private sector partners to the greatest possible extent, a requirement of successful bidding consortia would be to engage in long-term technical staff rotations, with ARL personnel working in our partners' labs and our partners' personnel working in our lab.
- For enhanced communication among each consortium's members, each member would have to be capable of video-teleconferencing.

This approach was intended not only to bring together the best of the private and the public sectors in responding to a technically demanding challenge, but also to respond to several of the other external pressures placed on ARL: it would increase outsourcing, help ARL to seek dual-use solutions, and use commercial standards and products.

FedLab was also to be a "research multiplier." The science and engineering (S&E) staff would be enhanced via the working relationships with the best of the private sector (including the staff exchanges). FedLab would take advantage of existing state-of-the-art facilities, and encourage the construction of new industry facilities. We also expected that IR&D (Independent Research and Development) would be refocused to support FedLab projects. Commercial technologies would be adopted and adapted to the military environment. And of greatest importance, we would be able to build an in-depth knowledge base and competence in the technology, despite the overall reduction envisioned for the DoD in-house work force. We would be able to do more with less!

It is also satisfying to note that in the Senate Armed Services Committee report on the FY95 Defense Authorization Act, the FedLab concept was highly praised, and additional funds were recommended to support it.*

2.3 Implementation of the FedLab Concept

After the concept was developed and approvals gained from the chain of command, the actual implementation of FedLab began in December of 1994 with the issuance (in hard copy and on the World Wide Web) of a Broad Agency Announcement (BAA) that introduced and described the concept, and specified the requirements outlined above. Five technical areas were defined for which consortia could compete. These were

- advanced distributed simulation,
- telecommunications/information distribution,
- software and intelligent systems,

*"***The Army's initiative to create an open, federated laboratory system is an innovative and forward-thinking approach.** *The committee supports the competitive selection of laboratories from industry and academia to work with the Army Research Laboratory to meet the Army research needs across a wide range of technologies. The committee recommends an* ***increase of $20.0 million*** *in PE 61102A to accelerate this effort."*

Source: National Defense Authorization Act for FY 1995, SASC Report, June 14, 1994.

- advanced and interactive displays, and
- advanced sensors.

It was planned to offer five-year CAs to one consortium in each area, with a government option to extend the relationship noncompetitively for an additional three years. The planned five-year investment was estimated to be approximately $175M.

After a draft of the BAA was announced in November 1994, two day-long presolicitation conferences were held, one on each coast, to explain the details and answer questions that potential bidders might have and to take comments for the final BAA to be released. Approximately 400 people attended each of these. To introduce potential partners to the ARL staff and programs, we held an open house in January 1995 at our Adelphi site, where the technical work would be done. Another 400 people came to walk through our labs, see actual ongoing work, and talk to our researchers. There were also many thousands of "hits" on our web page announcement.

We were very pleased that these efforts yielded 37 proposal packages, and that the consortia that were assembled to bid consisted of the leaders of digital technologies in the private sector. Interestingly, rather than the minimum three-member consortia required, most of the bidding groups contained from a half dozen to a dozen and a half members.

During the spring of 1995, a meticulous proposal evaluation process took place under the leadership of the Army Research Office (ARO) in North Carolina. Over 80 people were involved in the month-long evaluation.

However, before the five awards could be announced, Congress reconsidered its support of FedLab. Our concept had become caught up in (and, some believe, confused with) issues revolving around Federally Funded Research and Development Centers (FFRDCs). Despite last-minute efforts to separate our concept from the FFRDC issue, Congress reduced the funding and directed that only three technical areas be supported, and that the three-year extension option be dropped.

2.4 Current Status

The winning consortia were announced on 16 January 1996. The surviving three consortia with their membership and funding are as follows:

Advanced and Interactive Displays

Members:	Rockwell International (industry lead) Sytronics, Inc. North Carolina A&T Univ. (HBCU/MI) Univ. of Illinois Microelectronics Center of North Carolina
Funding:	$4.260M in FY97, $4.364M in FY98; approximately $25M over five years (HBCU/MI = 9.3 percent)
CAM:	Bernard M. Corona, 410-278-5916

Advanced Sensors

Members:	Lockheed Sanders (industry lead)	ERIM
	Clark Atlanta Univ. (HBCU/MI)	GTRI
	Univ. of New Mexico (HBCU/MI)	MIT
	Lockheed Missiles and Space Co.	Univ. of Maryland
	Texas Instruments	Univ. of Michigan
	Ohio State Research Foundation	Stanford Univ.
Funding:	$6.912M in FY97, $8.828M in FY98; approximately $50M over five years (HBCU/MI = 10.8 percent)	
CAM:	John Miller, 301-394-5000	

Telecommunications/Information Distribution

Members:	Lockheed Sanders (industry lead)	Bellcore
	Howard Univ. (HBCU/MI)	GTE Labs
	Morgan State Univ. (HBCU/MI)	MIT
	City College of New York (HBCU/MI)	Univ. of Delaware
	Univ. of Maryland	Motorola
Funding:	$6.533M in FY97, $8.610M in FY98; approximately $47M over five years (HBCU/MI = 12.0 percent)	
CAM:	Dr. John W. Gowens II, 301-394-1722	

This effort currently involves 87 scientists and engineers (S&Es) from industry, 71 from ARL, and 92 faculty, 120 graduate students, and 11 postdoctoral fellows from academia. Four different ARL directorates are participating.

The benefits of FedLab go in both directions. The Army gains the private sector's manufacturing expertise and related IR&D and academic research programs. Our FedLab partners gain a better understanding of Army-unique research and of the soldier's materiel requirements. In addition, to date the private sector has invested $5.3M in new facilities plus an additional $5.9M in internal coinvestment for use in FedLab programs.

The CAs have been in force for two and half years. In that time, the consortia organized themselves, formulated their program plans for FY96, and began work. Each program was divided into several technical thrusts or factors, each of which contains a number of tasks. Each factor is led by an external partner, and each task has an external principal investigator and several associate partners, including an ARL investigator. Figure 3 shows an example of this structure for the Telecommunications and Information Distribution consortium.

Each consortium had its first annual two-day technical symposium during January 1997, at which the results of its first year's work were displayed. Attendance varied among the three symposia from 180 to 350 people. There were oral presentations, poster sessions, and live demonstrations, all of which showed a remarkable technical effort with some very fine results. In addition, 144 technical papers were published and 14 technology transition contracts established with the RDECs and the Training and Doctrine Command (TRADOC).

			Sanders	Motorola	GTE Labs	Bellcore	U Maryland	U Delaware	MIT	CCNY	Howard	ARL
Wireless Battlefield Digital Comms	1.1	Wireless Battlefield Network Architecture Analysis		●	☆		●					✓
	1.2	Spectral Efficiency/Capacity Enhancement	●	☆		●	●		●			✓
	1.3	Adaptive Distributed Routing and Mobility Mgmt				☆	●	●				✓
	1.4	Wireless Information Systems for the Soldier	●		☆							
Tactical/ Strategic Interoperability	2.1	Modeling and Simulation of Heterogeneous Networks		●			☆				●	✓
	2.2	Heterogeneous Network Management				☆	●	●				
	2.3	Formal Specs/Interoperability Testing of Protocols				☆		●		●		✓
	2.4	Internetworking Interoperability				☆				●		
	2.5	Heterogeneous Intelligent Network Capabilities			☆	●						✓
Information Distribution	3.1	Networked Access/Mgmt of Heterogeneous Info	☆			●						✓
	3.2	Tactical Data Distribution and Situational Awareness	●	☆				●				✓✓
	3.3	Manipulation/Presentation of Remote Info Sources	●				●		☆			
Multimedia Concepts	4.1	Coding/Signal Processing Over Corrupted Channels	●				●	●		☆		✓
	4.2	Multimedia Compression Schemes	☆				●	●			●	
	4.3	Resource Allocation for Multimedia ATM Networks			☆		●					✓
	4.4	Adaptive Multimedia Protocol and Synchronization						☆		●		
Additional Innovative Research	5.1	Wideband Wireless Mobile Network		☆								
	5.2	Interoperabilility of Secure Networks			☆				●			✓
	5.3	Next Generation Defensive Information Warfare	☆			●						✓

☆ = Principal Investigator ● = Associate Investigator ✓ = ARL Investigator shading = Technical Factor Lead

Figure 3. Sample of research plan structure, showing program divided into technical factors (left column), each containing several tasks (listed); other columns show roles of consortium members (Telecommunications and Information Distribution consortium).

The FY97 program was completed, and the results were presented in February 1998. This year one single, week-long symposium was held with all three consortia reporting out at the same time. The FY98 program is now under way.

2.5 Assessment and Future Directions

Not unexpectedly, in the initiation of FedLab, some administrative and cultural problems arose. The administrative problems were fairly minor, mainly concerned with meshing three very different operating systems (government, industry, and academia) in terms of how funds were handled and how personnel were managed. The cultural problems revolved around the very different approaches that industry and academia take towards accomplishing tasks, the first being strongly driven by deadlines and deliverables, and the second more by investigation and publishability. However, this "culture shock" has, for the most part, worn off and, all things considered, is not a major problem.

Program contents have also required some readjustment; tasks and goals were redefined as the consortia began to get a better appreciation of the competencies of their members. It also became apparent that the ARL in-house contributions were very different in each of the three areas. For example, in the sensors area, ARL has a very strong program and thus takes

a leading role in that consortium; in telecommunications, however, our in-house program is very small, and so we have become more of a follower than a leader in this area from the standpoint of technical output. However, it has not been a problem for the three consortia to operate somewhat differently; rather, it is a sign of the flexibility of the FedLab structure. In all cases, though, leadership in the management of the consortia resides at ARL.

One observation made after the first year's three technical symposia was that, while a lot of excellent work has been accomplished, the integration of the various projects into a unified technical program has not yet taken place. Although this is understandable for the first year, attention has been focused on this goal during the second year. Such integration is critical to accomplishing the ultimate goals of FedLab.

It is intended to display the progress towards this integration at the third symposium, scheduled for February 1999. Again, there will be a single symposium with all three consortia participating. However, this time we will feature a number of cross-consortia joint papers, as well as a demonstration in the form of a wargame vignette that will merge the technology outputs of the three consortia into a single scenario of real-time situational awareness and data fusion and display.

Another area that will require more emphasis is the number of staff rotations. The BAA specified as a goal that 20 percent of the S&Es working in each area should be on long-term (one to one and a half years) rotation. At present, this all-important feature of the program has not reached the targeted percentage. However, currently there are 34 rotational assignments into ARL from our partners and 17 assignments of ARL researchers to our partner's labs.

An additional challenge, sometimes, is dealing with employees of our partners on rotation to ARL who are foreign nationals. Controlling their access to parts of the ARL facilities where classified work is going on has been something of a problem.

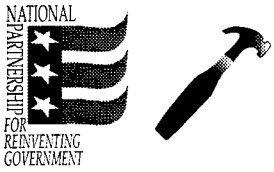
Overall, FedLab has assembled a lot of energetic people, working with enthusiasm and doing good technical work. The consensus among the managers involved with FedLab is that on a scale of 1 to 5, after two and half years, it gets a 4+.

If we believe that FedLab is on the right track and will be successful in helping ARL fulfill its mission, the obvious question is: "What next?" Several possibilities are currently being considered relating to the future of FedLab:

- Can we recapture the two technical areas that were not supported by Congress in the original digitization effort? (Advanced Distributed Simulation and Software and Intelligent Systems were deleted from the program.)
- Can we create a new consortium within the digitization effort, or expand an existing one, that will bring a private sector partner to work in the new world-class facilities about to be completed at our Adelphi campus?

- Are there whole new technology mission areas in which ARL could contribute by establishing other FedLab systems of partnerships similar to what has been done for the problem of digitizing the battlefield?

The last question in particular is very tantalizing, since there are a number of critical problems facing the future Army to which a massive technological assault could provide the solutions. These are now under active consideration, but are not yet ready for a public discussion.



We are exceptionally proud to note that on 1 July 1998 the Principal Deputy Director of the NPR and the Assistant Secretary of the Army presented ARL with Vice President Al Gore's Hammer Award for the FedLab reinvention. Of all the Hammers that have been given by the Vice President to teams of federal workers, this one may be unique, in that it was for the reinvention of the core business process of R&D, rather than for a functional support process.

As noted earlier, the FedLab concept is the fundamental reinvention that ARL has undertaken to enable it to better perform its mission in this time of decreasing resources and increasing requirements. The initiatives described in the following sections of this report all relate to or support, either directly or indirectly, this FedLab reinvention of the R&D process.

3. The Open Laboratory

The Open Laboratory initiative is a collection of operational procedures designed to support the large number of guest researchers that ARL is hoping to attract to our facilities. It also includes procedures necessary to help our people going on long-term rotations to other research organizations, both to our FedLab partners, and to other institutions within the worldwide scientific community. The Open Lab is designed to deal with the problems that naturally arise from such a flow. The concept of the guest researcher, both into and out of ARL, is also part of our larger vision of ARL as an intellectual crossroads and meeting place. This vision derives from the belief that a world-class research organization must be open to both ideas and people from elsewhere in the scientific community.

3.1 Description of the Open Lab Initiative

In a fall 1996 report entitled *Endless Frontier, Limited Resources: U.S. R&D Policy for Competitiveness*, the Council on Competitiveness (a nonpartisan, nonprofit forum of business, university, and labor executives) discussed what it considered a new approach to technological innovation. This approach is based on collaboration among industry, academia, and the federal laboratory system, which are the principal players in the nation's research and development enterprise. According to the report, collaboration often includes personnel exchanges to maximize the exploitation of resources represented by the skills and knowledges of the employees and the unique facilities of the laboratories. This report confirmed the need that we recognized to establish an "open laboratory."

The Open Laboratory concept was identified and initiated several years ago. ARL's Director, Dr. John Lyons, came to ARL in 1992 from a long career as Director of the highly acclaimed National Institute of Standards and Technology (NIST), where the use of personnel exchanges was so well established that the number of guest researchers was almost equal to the number of S&Es on the staff. Dr. Lyons touted the many advantages of having a flow of guest researchers coming into ARL to conduct research using ARL's unique equipment and facilities, as well as the benefits to ARL and its employees of ARL personnel spending time at other research facilities in industry, academia, or government agencies, for time spans ranging from two weeks to more than a year.

Becoming an open laboratory allows ARL to realize, to a large extent, its vision of itself as "an intellectual crossroads for the technical community." By *open laboratory*, we mean a research facility that permits easy access to its facilities by researchers from outside the laboratory, that supports its researchers as they work in other laboratories, and that actively encourages the exchange of researchers, ideas, information, and results with other laboratories.

In response to the Director's encouragement, the exchange of guest researchers in and out of ARL increased significantly. In 1993, 137 guest re-

searchers came to ARL, providing 25 full-time equivalent (FTE) work-years; only 28 ARL S&Es were guest researchers at other organizations, amounting to 5 FTEs of labor. By 1996, the number of guest researchers coming into ARL had almost doubled to 245 (66 FTEs), and the number of ARL employees going to other organizations as guest researchers had almost quadrupled to 110 (51 FTEs). Annual goals were set of 400 guest researchers coming into ARL by 2001 and 300 researchers going out of ARL by 2002. FedLab was an additional impetus to the Open Laboratory concept, because it specifically made provisions for personnel exchanges between members of our partners' staffs and ARL.

However, such openness brings with it a host of operational problems. Some of these are related to security, since some classified work goes on at ARL. Other problems are the ordinary issues that any organization would confront when trying to allow strangers to come and go with minimal restrictions, and at the same time providing support for their technical endeavors while on site. Rotation of our personnel out also raises as many issues as rotations of guest researchers in. The Open Laboratory initiative is an attempt to identify these various issues and potential problem areas, and solve them so that the vision of an intellectual crossroads can be achieved.

The principal areas of concern in bringing the Open Lab concept to fruition are security, use of the libraries, and the logistics of staff rotations, both in and out.

3.2 Problems and Recommended Solutions

3.2.1 Security

Emblematic of the Open Lab is the absence of guards at ARL's front gate during normal working hours. In the Cold War era, the guard post was always manned, and all staff and visitors were checked as they entered the compound. The rear gate was always closed except during rush hours, when a guard was also stationed there. Dr. Lyons felt that, much like NIST (which also has an unmanned guard booth at its gate), ARL must present an initial appearance of openness if true openness is to be attained.

However, there is a tension between the benefits of openness (maximum accessibility is essential to doing good science) and the requirement to provide physical security and protect classified work and materials. Despite the desirability of increasing the number of guest researchers at ARL, security concerns preclude allowing unlimited access to all who walk in the gate. The clearance process is intended to reconcile the opposing goals of security and openness. However, it does not solve all problems. For example, the law specifically limits the access that foreign nationals may have to defense materials and computer networks; thus, some clearances simply cannot be granted. More commonly, clearances are not received in order or in a timely manner, usually because our own researchers do not understand security requirements and fail to provide advance notice of

visitors to the security office. This results in the need to escort uncleared guest researchers, the requirement of which falls to the host researchers, distracting them from their main duties.

A problem in the past has been the lack of an up-to-date, accurate database that can identify all guest researchers on site. Management could not be assured that they knew, at any instant, who was here. This caused obvious security problems, not to mention problems of legal liability. This situation arose both from insufficient in- and out-processing procedures, and from the underutilization by the host researchers of those processes that do exist. In general, it appears that the security procedures that do exist were being enforced inconsistently, and there was confusion among our own S&Es as to the proper procedures. Much improvement has been made in both these processes and their implementation.

Further relief to this problem will be realized with the installation of a comprehensive database, now under construction, that will contain all the pertinent information about every employee, contractor, and guest researcher at any of ARL's sites.

As was found with most of the problems that Open Lab presented, the greatest hurdle to overcome was a culture change on the part of our own staff. Taking the guard off the gate has been compensated for by the use of that manpower to provide a higher degree of security inside ARL buildings, as well as a roving external guard presence in vehicles. Restricting uncleared visitors to certain routes within the buildings has been debated. A team of foreign nationals working at the Adelphi site has already been physically segregated in a laboratory facility specially built in an unclassified building that is separate from the main buildings. However, the ultimate answers to this problem will be increased emphasis on educating our own host S&Es on their responsibilities, and getting them to take these responsibilities more seriously.

ARL has also approached this problem as a technical challenge. Both on the battlefield and in the laboratory, computer security and information assurance have become a special problem. ARL has become a lead agency in information assurance and defensive information warfare research, and we are using our own laboratory computer systems as a test bed for our research for the field army. Thus, many of the hardware and software protocols being studied are being applied to the problems presented by guest researchers at ARL facilities.

3.2.2 *Libraries*

A well-run, well-stocked, and easily accessible technical library is absolutely essential to a world-class research organization. Within the constraints of budget and manpower, the libraries at our two main campuses have continually striven to provide the services and atmosphere required. However, FedLab and the increasing emphasis on guest researchers under Open Lab have created a new, if not unexpected, set of problems. The library at Adelphi and three of the four library sites at Aberdeen are inside

secured areas, thus causing the most obvious problem: access by visiting researchers whose clearance is not available. However, this is, by far, not the only problem. What should be the policy on letting nonemployees remove materials from the library? What level of service (e.g., in terms of complex and expensive literature searches) should be provided to nonemployees? This question is especially difficult when the requester is a contractor's employee doing a search for work not relevant to ARL. How do interagency library exchange agreements relate to non-ARL employees? Indeed, how do the library staff even recognize a guest researcher if his badge is not readily in sight, and, assuming he can be identified, how do the staff members know what projects he is working on and, therefore, authorized to use the library assets for?

Since libraries, like all other support functions, cost money and require personnel to operate, they must husband their resources: throwing the library's doors open to all comers is not a practical option. Little has yet been accomplished to deal with these problems. It has been suggested that library cards be issued to identify employees and different categories of guests. Some thought has been given to physically separating classified and restricted materials in the libraries and opening the unrestricted portion as an unclassified area. However, again the most basic thing that must be done is to obtain a clear understanding of the situation as it currently exists. To do this, a library committee was formed, held several meetings, conducted some surveys and investigations, and issued a report. We are now awaiting a decision on that report before moving on to implementation of its recommendations.

3.2.3 *Staff Rotations*

The problem of staff rotations is especially complex. Indeed, both in rotating a guest researcher in, or one of our own staff members out, we usually affect a person's entire way of living: spouse and spouse's employment, children and their schooling requirements, housing, transportation, etc. One cannot just tell someone to show up next Monday at a new job location hundreds or thousands of miles away and leave it at that. Although, at least in theory, the private sector can apply more pressure on its workers to take long-term assignments away from home, we in the government must persuade, cajole, and offer incentives for an employee to disrupt his or her life so drastically. Some significant issues for people considering rotations to laboratories outside ARL are the regulations on reimbursement for long-term travel, family impact (such as working spouses, school-age children, availability of quality child care, health care plans, etc), and the effect on promotion consideration.

The approach to rotations both in and out has so far been ad hoc; as rotations become more common, more formal procedures will be needed. For the most part, the situations have been handled case by case, without well-thought-out and published guidance. Prior planning has in many cases been minimal. The travel offices at the two main ARL campuses handle their processes differently. Travel reimbursements for long-term travel as-

signments have not been timely, and with the regionalization of all our finance and accounting functions, our concern in this area has increased. While a number of "band-aid" fixes have been implemented for many of these problems, a unified and coherent policy needs to be established and published. Publications such as a sponsor's guide for hosts of visiting researchers and a welcome package for the visitors are desperately needed, as is a guide for those rotating out on long-term assignments in our partners' labs.

Finally, there can be significant problems on reentry for an ARL staff member on a long-term rotation. Sometimes the researcher's office is waiting as it was left, and the program is in a pause mode. In this case, the worker just steps back into the picture as if he or she had never left. On the other hand, often programs are completed and new ones started, or the branch may have been reorganized or physically moved to new quarters. In these cases, utilization plans for the returning worker are necessary to reintegrate the person back into the ARL community. Unfortunately, with the various stresses on managers due to the current environment, these types of plans are not often done in any more than a cursory manner.

3.3 Current Status

An advisory group on implementation of the Open Lab was established, including both technical and support services employees. This group reported to the ARL Deputy Director, who was responsible for assuring the implementation of the Open Lab. This advisory group established a set of definitions of terms used in implementing the Open Lab. Because of the broad range of functions affected by the Open Lab, the advisory group recommended setting up subgroups as follows:

- a resources working group to determine the costs associated with rotations into and out of ARL;
- a rotations working group (1) to identify the issues and processes needed to make rotations attractive for ARL's S&Es and (2) to develop a rotations manual;
- a sponsors working group to develop a manual for ARL sponsors of guest researchers; and
- a legal working group to identify the legal ramifications and requirements involved and to document them in an Open Lab Legal Handbook.

The advisory group wrote an Open Lab concept paper identifying some of the main issues to be considered by the subgroups. These included the need to develop (1) a "welcome" packet for guest researchers to smooth their arrival; (2) a one-stop guest researcher orientation covering all in-processing and out-processing procedures; (3) training for ARL employees going on rotations and training for sponsors of guest researchers; (4) plans for managing space/computer/library/clerical needs; (5) means for maintaining security without impeding the guest's ability to work effectively; and (6) ARL policy providing rotation incentives.

Implementation of the recommendations has been uneven, mainly because of the downsizing of the support offices and the resulting increased demands on their time. The Open Lab Legal Handbook was published in August 1996, and the Open Lab Rotation Manual was published in July 1996, but the Sponsors Guide was not finalized, and the resources working group dissolved without accomplishing its mission. The issue of security and mobility of guest researchers is still being addressed and is being handled on an individual basis. The one-stop guest researcher orientation and the training for sponsors and employees considering rotations have not been developed, so the administrative burden for the technical employees is considerable and may be a barrier to meeting the Open Lab goals. This is also a direct threat to achieving the staff rotation goals of FedLab.

While there are many benefits to the Open Lab concept, it requires a culture change that may be difficult for some people to accept. The implementation of the Open Lab concept must have high-level ownership and be an integrated effort, with policies applicable across the laboratory. Orientations, training, assistance in finding challenging assignments for guests and for ARL employees going on rotations, and easing the administrative burdens of the Open Lab are issues that have been identified but not resolved. However, the rate at which personnel exchanges have increased in the last few years is encouraging. This suggests that as the issues identified are resolved, the rate of exchanges will increase further, and ARL can become the model of an "open laboratory."

4. A Reinvention Laboratory Under the National Partnership for Reinventing Government: Waivers

With the downsizing of ARL's staff, the impact of our relocations due to BRAC, and the inception of the FedLab initiative, it became evident that our remaining support staff would have more and different responsibilities per person; in order to cope with the new situation, they would need as much help and as little red tape as we could arrange. Being an NPR reinvention laboratory enabled us to obtain waivers to a wide variety of regulations and policies that were either irrelevant or duplicative, or in some sense overly constraining and time consuming. While no one waiver saved a large amount of money, we have been able to save a great deal of "process time," thereby allowing the support staff to serve the technical staff more efficiently, flexibly, and responsively.

4.1 Background

In February 1994, ARL was designated an NPR Reinvention Laboratory. We were actually grandfathered into the program, since we had been, in our former incarnation as Laboratory Command, a participant in the DoD Laboratory Demonstration Program. (The Lab Demo program had been established in 1989 in response to a recommendation of the Defense Science Board 1987 Summer study.) In the early days of the NPR program, quite frankly, we didn't understand it very well and didn't think much about it, except that using the Vice President's NPR logo seemed to add a nice touch to our briefing charts. It is probably also fair to say that in those early days, the NPR staff did not quite have a grip on their program, because we got precious little advice from them in terms of what it really meant to be a reinvention laboratory. Although the word "waiver" kept popping up (which certainly sounded like there could be benefits to being a reinvention lab), there was no process in place to gain waivers from rules and regulations.

Gradually it became apparent, however, that reinvention had more to do with changing the way an organization performed its mission than with how many waivers one could obtain. In fact, after being in the program for three years, we have realized that waivers to the really significant things that prevent true reinvention are simply too difficult for the system to deal with. If wholesale waiving of personnel and funding regulations is needed, we must achieve it by other means, such as through legislation.

Nevertheless, it has also become clear that the use of waivers can, indeed, be a very useful enabling device for a larger reinvention initiative. In ARL's case, there are a myriad minor rules, regulations, forms, and various other annoyances that, if done away with, could save the support staff, in particular, many hours of useless effort that could be better used in support of the technical staff. It was with this philosophy that we entered into the waiver hunt with great zeal.

4.2 Implementation: The "Old" System

Lacking any sort of guidance as to how waivers could be obtained, in March 1995 we dived into the process by devising our own waiver request format and preparing a set of 55 waiver requests, which we bound into a volume and started up the approval chain, accompanied by a briefing delivered to several members of the AMC and Army senior leadership. Of the 55 requests, most addressed six functional areas (human resources management, fiscal resources management, procurement, information resources management, capital assets management, and logistics), along with a few "miscellaneous." The requests were targeted at the agencies responsible for the regulations that we desired to waive. These included AMC headquarters (our parent command), Department of the Army headquarters, OSD, the Office of Personnel Management (OPM), the Office of Management and Budget (OMB), the Defense Logistics Agency (DLA), the Government Printing Office (GPO), and, for those regulations that we believed would require statutory relief, Congress.

Waivers were solicited from the members of the ARL staff, particularly the functional support staff. Although it took a little convincing to make them believe that this was a real opportunity for relief, many suggestions did come in. Each was vetted by management and by our Chief Counsel for appropriateness, completeness, utility, and "genealogy" (that is, responsible agency). The genealogy of a waiver often turned out to be particularly vexing, sometimes standing in the critical approval path. A member of the support staff would cite a regulation that was believed to be the cause of some problem or inefficiency; upon investigation, however, it often turned out that the particular regulation was either a derivative of a higher level regulation (which is what we really needed relief from), or was being implemented more stringently than required at a lower level, sometimes even internally at ARL. Thus, the legal review became extremely important. Even with this precaution, several waiver requests were returned for having incorrect cites.

The book of waivers was first briefed to the Deputy Commander of AMC, who took action on the spot to approve five of the six AMC waivers. He also gave us permission to take the book forward to the next level. We next briefed the Assistant Secretary of the Army (Research, Development and Acquisition), who was enthusiastic about our initiative and directed his staff to take charge of moving the rest of our waivers through the system as quickly as possible.

The results of this first effort were as follows:

Approved	9	
Denied	6	
Pending	9	(most of these were never heard of again)
Returned for rework	6	
Withdrawn	18	(most of these dealt with personnel issues that were subsumed into the personnel demo program; see sect. 6)
No response	7	
Total	55	

4.3 Implementation: The "New" System

While we were pressing forward with our book of waiver requests, several new processes were being instituted to bring some order to the system. On 23 May 1995, the Secretary of Defense signed a letter giving authority for any organization designated a Reinvention Laboratory or Reinvention Center to request waivers of any nonstatutory DoD rules, policies, or regulations. There were a few restrictions on what could be waived, but basically the policy was that if the request were not *personally* denied within 30 days by the Secretary or the Deputy Secretary, it would take effect. This policy letter was prepared by the Defense Performance Review office. (Soon after, it was disestablished and its functions assigned to the DoD Comptroller.) Thus, no review process was established and no reviewing responsibility determined.) This worked out very well for the field agencies who managed to send waiver requests into the system, since 30 days would pass with no word from OSD, and the waivers would take effect.

Unfortunately, this lapse of control was eventually discovered, and on 12 February 1996, the Deputy Secretary of Defense issued a new directive "improving" the waiver authority process by extending the waiting period to 90 days and making it considerably more complex. This modified DoD system envisioned various points of contact, a process for reviews, reclamas against denials, postings on bulletin boards, etc. However, none of it ever happened; the DoD waiver system was completely broken.

A new group of energetic OSD staffers then took hold of the problem, and on 2 April 1997 a memo signed by the DoD Comptroller introduced a new and truly improved system. We are now waiting to see how well it works, but hopes are high.

Meanwhile, on 14 August 1995, the Secretary of the Army followed the original DoD lead and took it a step further. He delegated responsibility for approving waivers of Army regulations and policies to the local organization's commander or director, with the only requirement being the notification of higher headquarters (this authority was subject to the same restrictions as the original DoD policy: i.e., only nonstatutory regulations could be waived, waivers could not affect the rights of employees or of bargaining units, and waivers could not augment any organization's resources). This policy has been the most flexible method for dealing with waivers.

However, on 4 November 1997, DA headquarters issued a memorandum promulgating a revised policy, which claims to "facilitate the process" and "assist in the resolution of differences between the requesting reinvention center or laboratory and the HQDA staff principal." Since there had been few, if any, such "differences" that needed resolution, this letter set off a firestorm of complaints, which went directly to the Army Chief of Staff. The unofficial feedback is that the headquarters staff should not interpose themselves in the reinvention process. We are all awaiting the official response from the Chief's office.

At the AMC level, on 26 September 1995, the AMC Commanding General gave local commanders and directors the authority to waive AMC regulations and policies (again subject to the same restrictions) by submitting requests to AMC headquarters and waiting 30 days for denials, failing which, the waivers become effective.

4.4 Current Status

To date, ARL has submitted a total of 117 waivers to be processed under both the "old" and "new" systems. Of these, 41 have been approved. These have been tallied in table 2 in two ways: by functional area and by granting authority.

4.5 Assessment of Waivers Program

A cursory examination of table 2 makes a couple of points obvious. The most fruitful areas have been logistics and the management of our facilities. This is not surprising, since these areas are not the lightning rods that personnel or fiscal resource management are; gaining such waivers does not generate the scrutiny or opposition that might arise in more sensitive areas. By the same token, gaining a waiver in these areas is not the seminal event that determines an organization's future. Nevertheless, the opportunities here are not trivial. For instance, a set of logistics waivers allowed us to reduce the number of items on our property books by fully 25 percent: we took 100,000 items off the books. This led to substantial savings in the nuisance workload of both support and technical personnel

Table 2. Status of waiver requests, by type and authority.

Category	Waiver status				Total waivers
	Approved	Pending	Disapproved	Withdrawn	
Functional area					
Personnel	2	—	2	13	17
Resource management	2	—	3	13	18
Procurement	4	—	2	9	15
Info. resource mgmt	—	—	1	1	2
Capital assets	5	—	2	1	8
Logistics	17	3	—	11	31
Miscellaneous	11	—	2	13	26
Total	41	3	12	61	117
Granting authority					
AMC	7	1	1	7	16
DA	24	2	6	26	58
DoD	9	—	2	16	27
OPM	—	—	—	7	7
OMB	—	—	—	1	1
DLA	—	—	1	—	1
GPO	—	—	1	—	1
Statutory	1	—	1	4	6
Total	41	3	12	61	117

during annual property inventories. Likewise, although many of the other approved waivers yield only small savings of support workload, these add up. At the very least, the waivers simplify our lives by removing many of the annoying and seemingly mindless chores that clutter our days. This saves precious time for concentrating on more important, mission-related activities.

The abundance of DA waivers could also have been predicted, since the DA waiver system has been the most flexible in terms of delegation of authority. In fact, it is the very essence of the NPR principle to empower employees—in this case, senior leadership at the organization level. In contrast, the fact that we have had any success at all with DoD waivers is only because we got our applications in before that system fell apart.

A large number of waiver requests were withdrawn for two principal reasons. First, several issues were addressed by other means. For example, most of the personnel waiver requests were withdrawn so that they could be included in the alternative personnel system demonstration (discussed in sect. 6). Likewise, other requests were withdrawn because they were overtaken by events, as other activities in which ARL has been involved took up their cause. Most notable among these activities is the Laboratory Quality Improvement Program (LQIP) (also discussed in sect. 6).

Second, some of the requests were withdrawn or disapproved simply because we did not do sufficient research or preparation, or frankly, we overreached.

We recently conducted a formal audit of our waiver program to determine its specific impact on funding and manpower savings, if any. The ARL Internal Review and Audit Compliance Office reviewed 34 of our waviers. The results which are shown in table 3, revealed only a few small dollar savings (some of them only one-time events). Neither have we found labor savings of the sort that could be used to take FTEs in bulk off our rolls. We have found some labor savings distributed throughout the lab. We have been able to eliminate many nuisance requirements, shaving a few hours off here or a couple of days off there from a variety of processes, mostly in logistics and procurement. Most of these result in time savings for the technical staff, in that they can obtain the needed support services with shorter waiting times. We have also been able to gain relief from regulations that were causing morale problems for staff members in particular circumstances, such as those on long-term rotations to our FedLab partners' research facilities, or those caught up in BRAC-related relocations. We have also been able to avoid doing silly things, like putting inventory control bar code stickers on relocatable buildings (a projected savings of 0.06 work-days per year!).

Table 3. Savings due to 34 waivers.

	One time	Annual
Cost	$96K	$230
Labor	313 mandays	1006 mandays
Process time	475 days	2127 days

An issue of immediate concern is the requirement that waivers were only to be for two years. That means that most of the waivers granted, not only to ARL but to the other LQIP labs as well, are running out. The expiration of these has temporarily been put on hold by all three services and OSD while possible approaches are being considered. For ARL, even though the waivers were less than an overwhelming success, nevertheless having to re-enter those 100,000 pieces of waived property on hand receipts would cause chaos. Thus, we are working through the LQIP for a more rational and permanent solution to this problem.

Despite the lack of dramatic cost and time savings that people seem to expect from these types of waivers, we intend to continue participating in the program to the greatest extent possible and to shape it to more strongly support the FedLab and Open Lab initiatives.

5. Business Process Reengineering (BPR)

The waivers obtained through our participation in the NPR tended to counter the burdens of regulations and policies externally imposed by higher headquarters. However, upon examination, we found numerous internally generated processes that were also creating time and manpower burdens on the technical staff. Through the techniques of Business Process Reengineering (BPR), we examined many of our own processes. Through this initiative, we identified numerous opportunities to realize efficiencies, which could facilitate the implementation of FedLab, as well as enable other internal programs to continue despite the continuing drawdown of support personnel.

5.1 What is BPR?

Business Process Reengineering is a fundamental rethinking and basic redesign of an entire business system, including processes, jobs, organizational structures, and management systems. It emphasizes the use of automation to improve process performance. By radically and dramatically changing business processes, BPR aims to increase process efficiency, effectiveness, productivity, and quality, benefiting both the organization and its customers.

When an organization experiences personnel drawdown (as ARL is), it is necessary to preserve as much as possible of the workforce responsible for "putting out the product." This was especially so as we began our FedLab reinvention efforts, since the FedLab was predicated on maximizing the leveraging that our technical staff could do with respect to our new external partners. Thus, the support staff must suffer most of the cuts. Cutting the support staff, however, risks reducing the technical staff's support to the point where the overall effectiveness of the organization suffers. The solution is to find ways to perform the support functions more efficiently with fewer people. Although some of this increased efficiency might come from waiving external rules and regulations (as discussed in the previous section), ARL also recognized the need to examine internal policies and procedures that might be outdated, outmoded, irrelevant, or inefficient. The methodology chosen was BPR, and it was implemented through a Business Process Reengineering Office established at ARL on a temporary basis.

The purpose of the BPR Office was to support ARL's efforts to attain a corporate information management environment in which personnel, financial, accounting, acquisition, and material functions operate uniformly throughout ARL. The assumption was that standardizing support processes, along with streamlining them, would increase overall efficiency. This standardization will also have the secondary benefit of helping to unify the seven formerly separate laboratories into a more cohesive entity.

Because ARL was formed from several pre-existing organizations (see the discussion of ARL's history in sect. 1), many business processes were performed differently at ARL's three major sites: the Adelphi Laboratory Cen-

ter (ALC) in Adelphi, MD; Aberdeen Proving Ground (APG) in Aberdeen, MD; and White Sands Missile Range (WSMR) in White Sands, NM. (Since the ARL units colocated with the NASA Langley and Lewis Laboratories rely on these NASA organizations for their support, they were not included in this BPR initiative.) The expected outcome of reengineering was that differences from site to site would be the exception rather than the rule. The BPR Office examined business processes to determine whether or not they were required, and if they were, the most efficient way to carry them out. BPR also identifies areas where information technology can improve activities within a given process. The overall objective is to transition the business processes from site-specific processes to consistent ARL-wide corporate processes, by using better business practices and automation support. The BPR Office limited its efforts to the business functions in the Office of the ARL Chief of Staff, the support arm of the laboratory. The scope of the BPR project was limited to the major support activities: human resources, financial management, logistics, and procurement. Table 4 shows the business units examined by the BPR Office and their relationship to the four functional areas.

The expectation was that BPR would lead to streamlined, efficient, and cost-effective business processes. It would identify the optimal integrated information system to be developed to support the business needs, and it should make visible the strengths and weaknesses in the organization's business processes.

5.2 BPR Implementation

BPR is a comparative analysis of where we are today with where we should be in the future. It determines where we are today through the development of a "Type I Enterprise Model." This model, a high-level overview of the organization's structure and functionality, documents where business functions are performed in the current environment. It serves to highlight functional duplication. Based on a series of interviews with senior management, functional heads, and key personnel in both the S&E and the operational units, high-level finance, resource, and infrastructure models were constructed.

Table 4. Business units by functional area.

Human resources	Financial management	Logistics	Procurement	Mixed functions
Human Resource Mgmt Div	Resource Mgt Div	Logistics Mgmt Div	Procurement Div	Legal Office
Equal Employment Opportunity Office	Program and Budget Office	Infrastructure Mgmt Office	Small and Disadvantaged Business Utilization Ofc	Technology Transfer Office
Manpower and Force Analysis Branch		Public Works Div	Competition Advocate	Law Enforcement and Physical Security Div
		Risk Mgmt Div		

The next step was to formulate the "Type I Best Practices Model," as determined through benchmarking against organizations considered to be "best in class." The Best Practices Model documents where business functions should be performed and projects functional efficiencies and improved internal controls.

In order to formulate the Best Practices Model, the BPR team conducted benchmark interviews with Malcolm Baldrige and Presidential Quality Awards winners and finalists, such as IRS Ogden, IBM Rochester, Eastman Chemical, NASA Lewis, U.S. Patent and Trademark Office, Xerox, Selectron, and Motorola. Interviews were conducted with a cross section of key personnel at each organization. Special emphasis was given to comparable functions at ARL, in particular, purchasing and receiving, financial management and control, human resources, and information resources.

Finally, the BPR team performed a gap analysis by comparing the Type I Best Practices Model to the Type I Enterprise Model. This comparison identified opportunities to eliminate redundant functions and to realign functions in order to improve processing or internal business and quality controls. Improvement opportunities were based on four primary criteria:

- identified standard best industry practices,
- estimated improvements in processing time,
- estimated improvements in customer service, and
- reduced cost.

5.3 Findings of Type I Analysis

The BPR Office predicted that, as a result of implementing the reengineering opportunities, ARL support staff would be able to deliver an improved level of service to the technical staff without redundant functions or unnecessary costs; internal business and quality controls would be maintained or improved; and all primary functions would be retained.

Examining best practice trends revealed several important opportunities for the alignment of functions and processes relative to the total ARL organization. For instance, by retaining a backbone of corporate administration and support functions organized into expert cross-functional support services teams, ARL could eliminate redundancies and improve service. In order to promote customer service and advance the ability of the support teams to understand the technical mission of the units they support, the supported units should evaluate the performance of the teams. Also, promotions, awards, and professional development of the support team should be linked to the needs and evaluations of supported units.

5.4 Type II Reengineering

With the completion of the macro-evaluation, the next step is a more in-depth examination of processes, called "Type II Reengineering." Here the

BPR Office used a software package to model dozens of individual processes in the identified functional areas. This modeling effort sought to understand all the steps involved in these processes, and then identify for elimination those that do not add value. The model examines the inputs, outputs, controls, and mechanisms for each process and lays them out (see fig. 4 for these features of the process "Issue Travel Orders"). First, an "as is" model is formulated, representing the current state of the process being modeled, without any specific improvements included. At this time, costing information is obtained for each activity within the model. (The "as is" model was usually different at ALC, APG, and WSMR, and the modeling was conducted separately at each site.) Then, a "to be" model is formulated, representing the proposed future state as a result of the redesigned process. The basic "to be" model is the same for all sites, representing one unified ARL approach with standard business practices across ALC, APG, and WSMR. Costing information is also estimated for the activities in the reengineered "to be" model, allowing comparisons to be made. The differences in cost and the quantity of full-time work-years between the "to be" and the "as is" models are the potential savings that are projected to be achievable upon full implementation of the recommendations.

Surveys of leaders in functional areas yielded a comprehensive list of processes nominated for this Type II examination. In the end, the processes were pared down to the following list for the detailed Type II Reengineering, and detailed sets of recommendations were made to improve each process:

- acquisition plan of execution
- ammunition handling
- awards
- complaints/grievances
- cooperative agreements

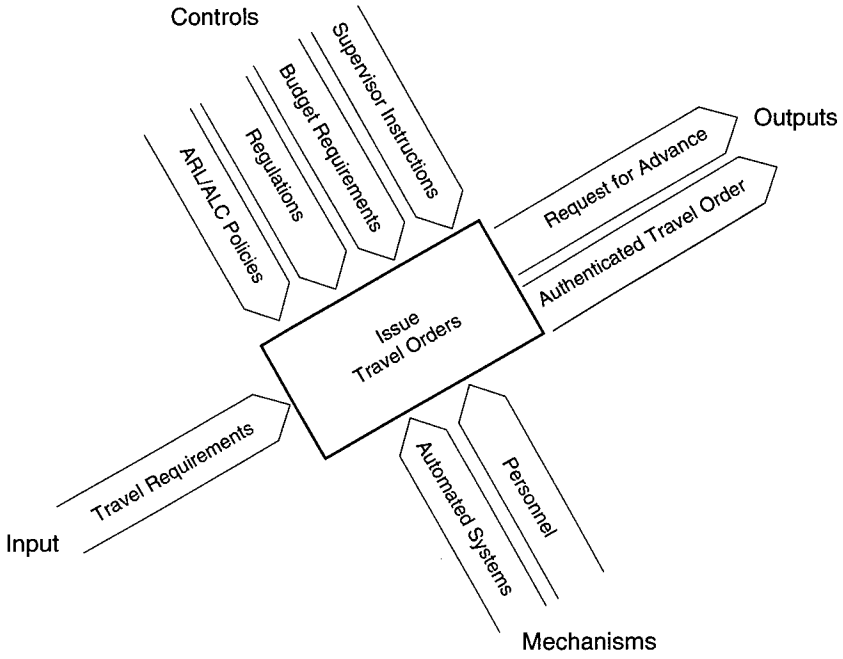


Figure 4. Business process reengineering example.

- cost/price analysis
- formal contracts
- funds control and distribution
- General and Administrative (G&A) overhead rate calculation/application
- indirect overhead rate calculation/distribution
- internal operating budget
- lateral transfers
- long-term training
- obligation forecasting
- personnel actions
- risk management pharmacy operations
- small purchases
- storage procedures
- technology planning
- training
- travel orders
- turn-ins
- unliquidated obligation reviews

5.5 Current Status, Assessment, and Future Directions

ARL senior management was briefed on the BPR Office's recommendations in the areas listed above. It is projected that if these recommendations are fully implemented, the reengineering will save over 70 FTEs in manpower *per year* across ARL, which equates to approximately $3.5M in savings *per year*. For example, to produce the standard Request for Personnel Action, SF-52, BPR analysis showed how to reduce the current 31-step process to 17 steps, with a projected annual savings of 9.25 FTEs and $460K.

Such savings can be realized once full implementation is complete. Table 5 shows these savings by groups of processes within each functional area. It is important to note that all FTE and dollar savings do not necessarily come from one particular functional area, but may be spread across multiple areas, including the technical directorates.

ARL is moving to put these reengineered processes into place. Implementation has already begun for personnel actions, training requests, awards, travel orders, and small purchases. Two cross-functional teams, which were designed to support the recommendations of the reengineering efforts, were formed and began working in 1996. These self-managed teams,

Table 5. Annual projected savings identified through reengineering at ARL.

Process areas	Annual saving ($)	Annual FTE savings
Financial mgmt	502,383	9.5
Human resources	790,629	17.1
Logistics	473,877	8.3
Procurement	1,635,923	38.3
Total	3,402,812	73.2

made up of people in all four functional areas (plus a team leader), were supposed to provide "one-stop shopping" for the technical staff to obtain support functions. The teams had to struggle with the usual obstacles inherent in changing the old ways of doing business. They had to define their identity and roles, and deal with obstacles placed in their way by reluctant players in the system. Although the teams had begun implementing some of the reengineering recommendations, additional downsizing and streamlining of the Chief of Staff's organization resulted in the teams being disbanded and the members returned to their prior organizations.

Has reengineering at ARL gone as expected? The answer is yes and no. The processes scheduled for reengineering have been defined. Although some modifications were made to the process list, the BPR effort covered substantial ground in the four functional areas of human resources, financial management, procurement, and logistics. However, full implementation has not occurred, mainly because of the lack of an adequate automated management system.

The BPR Office completed its analysis and prepared the summary documentation, including all the recommended process changes. The report was submitted to the ARL Director and the Chief of Staff for their consideration. The office was then disbanded.

Since that time, automation efforts have been redoubled. We now have a completely automated personnel action and position description system, which was brought on line as part of the personnel demonstration program (see sect. 6.) We are also about to inaugurate a completely automated purchasing system and an automated travel system. In addition, an on-line supply system has been running very successfully for about a year. Thus, many of the BPR recommendations have indeed been enacted, although not always in the way they were originally conceived.

6. Laboratory Quality Improvement Program (LQIP) and Alternative Personnel System Demonstration

In the search for mechanisms to enable ARL to operate more efficiently, we participate in the Laboratory Quality Improvement Program (LQIP) initiative. Our hope was to obtain additional flexibilities beyond those that NPR and BPR could deliver. As originally conceived, LQIP promised a means of achieving relief from DoD-wide constraints, as well as from statutory barriers to efficient operation. A number of initiatives were undertaken under the aegis of the DoD's Director of Defense Research and Engineering (DDR&E). Most were less than completely successful. However, the one major area of impact for ARL is the alternative personnel system demonstration, which will enable us to manage our people in a more rational manner, free from many of the constraints of the traditional civil service system. This is important for any research organization, but will be especially useful as we continue to reinvent ourselves under the FedLab concept.

6.1 Roots of LQIP

Over the past 30 or more years, more than 50 studies of the Defense laboratory system have repeatedly identified the problems of excessive and inappropriate rules and regulations and of external micromanagement, both of which reduce productivity and effectiveness. In 1987 the Defense Science Board, during a summer study of the management of the DoD technology base, expressed great concern about the quality of the in-house laboratories and observed that the inefficiencies in the system were only going to get worse, thereby reducing the effectiveness of the labs even further. The Board recommended to the DDR&E that a program of improvement and rejuvenation be instituted within the DoD labs in order to allow them to function more like private sector labs. Accordingly, in November 1989, the laboratory demonstration (Lab Demo) program was established by the Deputy Secretary of Defense. Its charter was to identify the most effective corrective actions for the long-recognized systemic problems in the management of technical staffs (and the various support functions that should empower those staffs), and obtain the authorization to implement changes.

Although a number of innovative ideas were proposed under Lab Demo, few were acted upon. In 1994, the new DDR&E decided to re-energize the program; the LQIP initiative was instituted. Its participants were the original Lab Demo labs. Within the Army, this included, in addition to ARL, the Research, Development and Engineering Center of the Missile Command (MRDEC), the Waterways Experiment Station (WES) of the Corps of Engineers, and the laboratories of the Medical R&D Command. The other Services were also represented by several laboratories each.

6.2 Implementation of LQIP

In March 1994, LQIP was designated the "DoD Science & Technology Laboratory Demonstration Program Reinvention Laboratory" by the NPR. Thus, ARL became one of the science and technology (S&T) reinvention

laboratories under this umbrella. LQIP is managed by an Implementation Panel that comprises the Service S&T executives (or their representatives), and reports to the Deputy DDR&E (LM&TT—Lab Management and Technology Transfer). Its basic purpose is to take on problems of common interest to the labs in all three Services; it either works for policy/regulatory relief, or prepares legislative packages to obtain statutory relief. The Implementation Panel was chaired by an Army representative for the first two years; the leadership was then passed to the Navy. Under the panel are five subpanels:

- Legislative Subpanel—seeking legislative relief from limitations on military construction. (This panel was recently redesignated the Facilities Subpanel.)
- Financial Subpanel—seeking to develop and implement a new financial system that will enable a more businesslike approach to the operations of the S&T reinvention labs.
- Personnel Subpanel—managing the planning process for the proposed alternative personnel system demonstration.
- Information Infrastructure Subpanel—assuring that DoD S&Es can maximize their use of the information tools available.
- Waiver Subpanel—addressing several issues not falling under the purview of the other subpanels.

ARL has been an active participant in all these subpanels, except the Legislative/Facilities Subpanel. A new Procurement Subpanel has just been chartered, for which ARL is supplying the Army representative.

6.3 Assessment of Current Status and Future Directions

On 3–4 February 1997, the Deputy DDR&E(LM&TT) chaired an offsite meeting of the Implementation Panel to assess the accomplishments of the past three years and LQIP's role in the future. The basic scorecard for LQIP's accomplishments was not impressive:

- Resolve Defense Management Review Directive (DMRD) conflicts—A number of Directives came out of the Defense Management Review in 1988 that, while appropriate to other organizations within DoD, were completely inappropriate for R&D organizations. These had been brought to the attention of then-Deputy Secretary of Defense Atwood who, in October 1992, approved in principle that R&D organizations should receive partial or total relief from several of these DMRDs. This would have, among other things, avoided the current ongoing regionalization of several of the support functions. However, Atwood failed to sign the order for this before leaving office. Although LQIP tried to follow up on the several DMRDs in question, it failed on every one.
- Raise the minor Military Construction (MILCON) budget—This action involved a legislative package to raise the minor construction limit from $300K to $1M, and the unspecified minor construction limit to $3M. This

effort was successful and resulted in a two-year test program in the FY96 Defense Authorization Bill. The test period is running out, and legislation is being sought to extend it.

- Increase small purchase threshold—An effort to increase the small purchase limit from $25K to $100K began as an LQIP initiative, but was picked up and enacted government-wide by the FY95 Federal Acquisition Streamlining Act. This is probably the most significant LQIP accomplishment.
- Use Cooperative and Other Agreements—The authority to use Cooperative Agreements was delegated to the labs as a result of this LQIP initiative. This authority was critically important as the enabling waiver that allowed our FedLab reinvention initiative. The authority to use Other Agreements is still at the OSD level and, for the most part, is being used only by the Defense Advanced Research Projects Agency (DARPA).
- Allow labs to manage to budget *versus* manage to budget *and* to FTEs—The thrust of this waiver was to allow laboratories to manage their personnel resources strictly based on what types and numbers of people their budgets would allow. This is in contrast to the current practice of a lab director being constrained not only by the budget, but also by a collection of nonbudgetary limits or caps on numbers of people, kinds of people, grade levels of staff members, and so forth. Although the idea of managing to budget only was initially stressed by the NPR, the concept never got off the ground for the labs—this, despite the fact that at the Second National Reinvention Revolution Conference held on 7–9 April 1997, the Vice President stated in direct and unmistakable language that managing by FTE levels was no longer to be practiced.
- Streamline R&D procurement procedures—The improvement was approved by the Defense Acquisition Review Council for a test, but it has seen only limited use.
- Establish Alternative Personnel System—The FY95 Defense Authorization Act authorized the use of Alternative Personnel Systems. (See sect. 6.4 for a discussion of progress.)

With this track record, LQIP seems to have been something less than a blazing success. However, the members decided to continue the process, if for no other reason than to provide a forum for senior S&T managers from the lab system to work together on common problems, as well as to provide assistance to the Deputy DDR&E (LM&TT) in his efforts to be an advocate for our interests.

6.4 Alternative Personnel System Demonstration

The effectiveness of the Defense laboratories has been studied by a variety of blue ribbon panels, committees, and commissions for at least four decades. Every one of these studies has concluded that the principal problem that the labs have in fully exploiting their capabilities is the civil service personnel system. The system introduces delays in performing even the simplest personnel actions. It ties the laboratory director's hands in such crucial areas as hiring, promoting, disciplining, training, restructur-

ing, etc. This system is agreed to be the single most important barrier preventing in-house government labs from functioning with the same efficiency as their sister labs in the private sector, and this argument has been frequently used as a rationale for privatizing the labs or turning them into GOCO (government-owned, contractor-operated) operations.

For ARL, this problem was particularly vexing, since as the Army's "corporate" laboratory, we would be compared to world-class laboratories like the legendary Bell Labs, which does not suffer from such crushing constraints on the way it manages its personnel. Furthermore, if we were to be able to implement certain planned aspects of FedLab, we would very definitely need relief from the existing system.

The opportunity to address this long-standing problem came when the FY95 Defense Authorization Bill, Section 342, empowered the Secretary of Defense to make the 15-year-old "China Lake" personnel demonstration experiment permanent, and to expand it to the other S&T reinvention laboratories. This authority was delegated to the DDR&E to implement, and LQIP was the mechanism chosen to carry out this implementation. The LQIP personnel subpanel has been guiding and coordinating the preparation of the personnel demo proposals from the S&T reinvention labs in all three services. Although the plans vary in detail, they are all aimed at allowing labs to hire and retain the best and the brightest from the scientific and engineering communities, and to deal with human resources more in the manner that the private sector does.

The ARL proposal was submitted along with those of the other Army S&T reinvention labs. The features of the ARL proposal include

- speed and flexibility in recruitment, hiring, and placement,
- simplified separation,
- pay for performance,
- simplified classification (pay banding, including a new senior-level band; see fig. 5),
- improved staff development program, and
- a simplified rewards system.

Figure 5. Career paths and pay bands.

Career paths	Bands														
Engineers and Scientists		I				II			III		IV		V		
E&S Technicians				I				II		III					
Administrative		I				II			III		IV		V		
General Support		I			II			III							
Corresponding GS grades →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	ST

The goals of the program are to

- improve hiring and allow ARL to effectively compete for high-quality personnel,
- motivate and retain high-quality staff,
- strengthen the manager's role,
- increase the personnel system's efficiency,
- revitalize the research intellect by facilitating personnel training, acquisition, and staff mobility,
- remain budget neutral by managing to in-house budget,
- create a model that can be exported to other agencies, and, of central importance,
- facilitate the FedLab concept of operations through simplified and more flexible staff management.

The initial Army proposal (dated 11 April 1995) went through numerous iterations, and three joint AMC-DA-DoD-OPM reviews. The reviews identified problem areas in the proposal and provided potential solutions and additional innovations not previously identified. Along the way, several important features were designated "Protected Corporate Interests" by DoD and removed from the proposal. These included relief from

- high-grade controls,
- the priority placement program,
- PBG (Program Budget Guidance)/FTE controls, and
- regionalization of the DoD Civilian Personnel Offices (CPO).

Although relief was sought by the DDR&E personally, none was granted. Even the intervention of the NPR staff at the direction of the Vice President was not successful. With these critical features removed, the plan was approved by the Army and forwarded to DoD on 13 December 1996. After DoD and OPM approval, the proposal was published in the 12 March 1997 Federal Register, and a copy provided to each affected employee. The required public hearings were held on 17–18 April 1997.

The proposal was approved by DoD, concurred in by OPM, and published in final form in the Federal Register on 4 March 1998. The resulting Alternative Personnel System Demonstration plan was implemented at ARL on 7 June 1998.

The work force was involved in the planning through a Staff Members Committee, which facilitated communication of the various aspects of the proposed demo and assured the work force that there would be no abridgment of their rights. The plan was also coordinated with the unions and has received their approval and buy-in to the process.

ARL established a program management office and an executive steering committee to manage the process and interface with the Army and LQIP officials involved with the overall implementation of the Congressional directive. Now that the demo is successfully under way, we are hopeful that at least some of the barriers to personnel management in the DoD laboratory system will be removed, although the more complete relief we had sought will have to wait for further initiatives.

On 24 February 1998, Principal Deputy Director of NPR and the Secretary of the Army presented the Vice President's Hammer Award to the Personnel Demo team in a ceremony at the Pentagon.

7. A GPRA Pilot Project in Performance Measurement

In order to assure themselves and the American taxpayer that the government was indeed delivering results for the money it spent, Congress enacted a law (the Government Performance and Results Act of 1993, PL 103-62—GPRA) requiring all agencies to operate on a results-oriented basis. That is, each agency was to produce long-range strategic and annual performance plans with quantitative descriptions of outcomes that could be expected as a result of its operations. This concept, if not easily accommodated in many areas of government operations, was particularly vexing for the research community. However, seeing GPRA as an opportunity to instill businesslike practices in our R&D operations, ARL volunteered to become a pilot project under the law, and to develop experimental techniques in managing a field that has been notoriously resistant to management, despite many decades of work in the area. The results of our efforts have been widely lauded as innovative advances in the state of the art in R&D management.

7.1 Historical Context of ARL's Participation as a GPRA Pilot Project

When ARL was activated at the beginning of FY93, the Acting Director decided that beginning a new organization afforded an opportunity to introduce new management practices, so that we might function more like a private sector R&D laboratory. These new practices specifically included business planning and performance evaluation—which, coincidentally, were the two basic components of GPRA.

Management planning and measuring has long been studied for application to the world of R&D. Management literature is replete with writings going back many decades in both planning and measuring. However, no approaches, particularly in the area of performance evaluation, have ever been found to be completely satisfactory for R&D, especially when compared to the planning and measuring techniques used in other types of business functions. This has been found to be so not only in government, but in the private sector as well (despite the common view that the "bottom line" is a suitable metric for all of a company's activities). Industry is struggling with the same issues that GPRA lays before the in-house government research organizations.

The reasons for this difficulty with R&D management are well known:

- the likely outcomes of research are not usually calculable in advance;
- the knowledge gained from research is not always of immediate value (there is a long time lag between inputs/outputs and outcomes), nor can that value always be determined or quantified in advance;
- results are more often serendipitous than predictable;
- there is a high percentage of negative findings in research, which, while often very useful themselves, are not valued as outcomes in the GPRA sense;

- the path by which the results of research are transitioned into products is not straightforward and is usually populated by a large number of different individuals and organizations; and, most simply,
- the unknown cannot be measured.

Even though the "D" of R&D is somewhat more amenable to planning and measuring than the "R," the difficulty of evaluating R&D is still daunting when compared to many production or service functions.

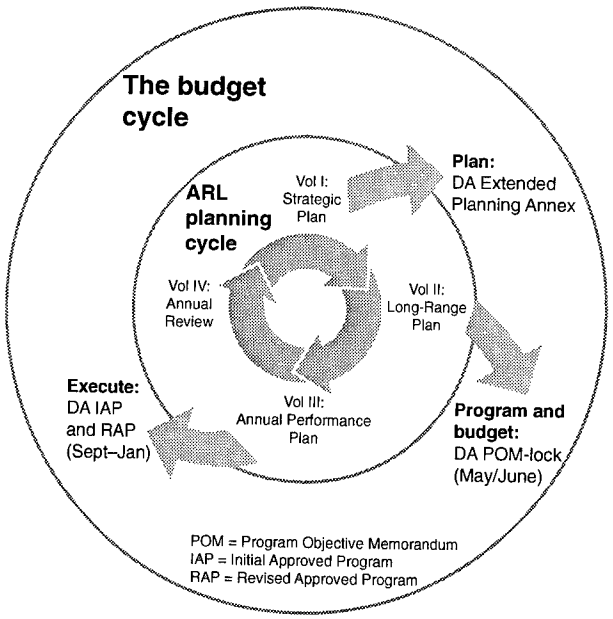
Despite this background, and with many research managers carrying the scars of previous attempts at both planning and measuring in the research environment, ARL decided to try again to produce a business management system that could be tailored to the unique R&D environment and yet be logical, rational, meaningful, and above all, doable, and that would add value to the laboratory. When GPRA came along, ARL had invested almost two years of effort in the planning and measuring processes; at that time, we decided that we were in as good a position as anyone to help the federal R&D community determine how it should be assessed by OMB and Congress. Therefore, in March 1994, ARL submitted a proposal to OMB to become a Phase I (Performance Measurement) pilot project. OMB officially designated the laboratory a Pilot Project for Performance Measurement on 6 July 1994. This designation made ARL the only R&D laboratory in the government to be included in the GPRA pilot process. As such, we have had a responsibility to our research colleagues throughout the government for representing their interests as OMB and Congress worked towards the government-wide implementation of the Act.

7.2 Business Planning at ARL

A major initiative instituted at the time of ARL's activation was a fairly sophisticated business planning process. This was centered around a four-volume business plan, the production of which was tied to the annual budget cycle of the Defense Department (fig. 6):

- Volume I, the *Strategic Plan*, looks out 10 to 15 years and, beginning with our mission and vision statements, assesses ARL's long-term goals, the business environment, the users' long-term requirements, ARL's strengths and weaknesses, etc.
- Volume II, the *Long-Range Plan*, looks at the resourcing of the *Strategic Plan* over the next six years (the "POM," or Program Objective Memorandum, period) in terms of funds, personnel, and facilities, based on projections of the DoD budget process.
- Volume III, the *Annual Performance Plan*, takes the strategic goals from Volume I and the resources from Volume II, lays out the projects and resources for the coming year, and, to the extent possible, sets quantifiable metrics against which performance will be measured.
- Volume IV, a corporate-style *Annual Review*, reports at the end of the year the degree to which the proposed goals in the performance plan were accomplished.

Figure 6. ARL business planning cycle coupled to Army PPBES (Planning, Programming, Budgeting, and Execution System) cycle.



When GPRA was enacted, it became clear that Volumes I, III, and IV were in alignment with the Act's requirements, with Volume II filling the role of a supporting document to Volume I. These plans are developed and updated at an annual cycle of quarterly meetings held by the ARL Director and his senior management team. The timing of these meetings and the resulting updated documents is tied to the annual budget cycle, so that the information is available for submission through Army headquarters to DoD in a timely fashion.

7.2.1 *ARL Strategic Plan*

The *Strategic Plan* contains an introductory discussion about the ARL mission and vision, along with some broad statements about long-range policies. It continues with a brief explanation of the plan's relationship to other DoD and Army planning documents and processes. The last part of the introductory material is a discussion of Army requirements and needs in the near, mid, and far terms.

The heart of the document is made up of sections for each of ARL's primary mission areas (digitization and communications science, armor and armaments, soldier system technology, vehicle technology, and survivability and lethality analysis). For each of these, a statement of strategic intent is followed by several long-term goals, each associated with a desired outcome.

These missions are also cast in terms of "Grand Challenges" to the directorates which are a way to encapsulate overarching needs of the Army into strategic technical vectors for ARL. The five Grand Challenges enunciated by our Director for ARL are

- provide weapons systems technology for the Future Combat System (FCS),
- provide lighter, faster, more fuel-efficient mobile platforms to enhance deployability and reduce the logistics tail,

- provide commanders unprecedented real-time situation awareness of the battlefield,
- significantly improve the battlefield soldier's ability to absorb information and make decisions, and
- solve the defensive information warfare problem.

As an example of the association of the strategic intent statement with goals and outcomes, take the armor/armaments mission area. The strategic intent states: "ARL will advance armor and armaments technologies to provide the 21st century soldier with the ability to overwhelm forces with minimum casualties and collateral damage and to survive against a range of current and future threats." One goal that follows from this is to "create designs for advanced armors ... that offer enhanced combat survivability and significantly reduced weight," with the outcome of "Increased protection through lower cost/lower weight passive armor concepts."

This example illustrates the concept of the "planning thread," which starts from the organization's mission and vision statements and can be followed through the planning process to the individual S&E at the bench. In the example just cited, the goal of a lighter armor arises from the fact that the Army of the future will be primarily based in the United States rather than overseas and thus will need to be more readily deployable in time of crisis. The current main battle tank is too heavy for more than one at a time to be carried on an air transport. A significant reduction in the weight of the armor would allow two to be carried per plane, thus halving the number of transports and the amount of time required to deploy an armored unit overseas, as well as the amount of fuel required. Based on this strategic goal, we have a program to develop a composite armor material that will provide ballistic protection equal to current armors, but weigh 25 percent less. From such a strategic goal, we can then derive a host of short-term technical goals that can be expressed in the annual performance plans for the next several years. Thus, the materials scientist working on the chemistry of composites can "follow the planning thread" to see where his work connects to the overall mission of ARL and to the Army.

This approach is obviously more amenable to requirements-directed work, that is, applied research or development. However, it can also be applied, at least in a limited fashion, to our basic research program. The assumption is that all research, no matter how basic, is undertaken for some purpose and with some goal in mind, even if far removed from an end-item application.

The strategic plan is discussed and developed or modified every year in late January at the second quarterly (or "Q2") meeting of the Director and his senior staff and directorate heads (SES level). The timing allows for major changes in the organization's goals to be submitted to the following year's budget preparation. The effort is very much top management driven, with all the senior managers bringing to the table their experiences and contacts from the past year with headquarters, users, and customer personnel. The Director's staff then transforms the results of this meeting into the actual document.

7.2.2 *ARL Performance Plan and Performance Report*

The performance plan is structured in three sections. The first section deals with management initiatives and goals. About a dozen goals are described for the coming fiscal year, dealing with things like the implementation of the FedLab concept of operations for ARL, progress on major BRAC construction projects, and other significant management undertakings. The second section covers the technical objectives. Here the heads of each of the technical directorates present their top five objectives to be achieved in the upcoming year's technical program. These objectives are only one or two sentences long and, to the greatest extent possible, state some quantifiable attribute or parameter to be attained (e.g., "use nanofabrication techniques to fabricate a 2×2 prototype spatial light modulator for optical image and signal processing. The modulator will exhibit picosecond switching speed with an average contrast ratio of 100 when switched with only 10 V"). Again, note that this type of quantitative statement is certainly applicable to applied work, but only in a more limited sense to basic research tasks. The third section of the plan lays out the year's goals for the metrics that the Director wants to emphasize (metrics are discussed in sect. 7.3.2).

An ARL-wide summary version of the performance plan has been submitted to OMB every year in compliance with the GPRA pilot process. We also prepare a second version containing an additional breakout of objectives and goals by directorate. Because of its greater size and emphasis on detail, this version is for internal use only.

The annual performance report is also structured in three parts. The first part is a brief discussion of the overall state of the lab and then a fairly extensive review of the past year's accomplishments, technical and otherwise. The annual report correlates these accomplishments with each of the objectives set forth in the performance plan published at the beginning of the fiscal year. This presentation includes the quantitative goals that were met or not met. For example, in our FY93 performance plan (pre-GPRA), one goal stated "Demonstrate a fully *automatic synthesis tool for creating VLSI* [very-large-scale integration] *chips.*" The FY93 *Annual Review,* published 14 months later, reported this accomplishment: "Expanded the institutionalization process for electronic design automation methodology through the development of a *computer-aided design synthesis tool for VLSI circuits.*"

The second part of the annual report contains a review and analysis of the lab's performance over the past year. Fiscal, personnel, and facilities data are presented graphically, with explanatory notes and discussion. This section presents the metrics, again in terms of the goals from the performance plan and the accomplishments for the year, along with appropriate discussion of the results and any variances from the plan. The final section of the report (published as a separate volume) is a listing of all the patents received and all the papers and reports published during the year.

Volume II of the business plan, the *Long-Range Plan*, is not submitted as part of the GPRA pilot process. It is a fairly weighty document for internal use only. It describes in great detail the fiscal and personnel resourcing of the strategic plan. It analyzes the finances of each directorate at the project level for the next six years and identifies potential problem areas requiring senior management's attention.

7.3 Performance Evaluation at ARL

A second management innovation introduced just before ARL's activation was a methodology to evaluate the health and performance of the laboratory. R&D performance evaluation has been a problem that has eluded a satisfactory solution for many decades. Efforts in this area have fallen into one of three approaches:

- Retrospective anecdotal reviews. These are usually impressive and meaningful to the technical community, but not to the senior agency leadership, who want to be able to define specific progress towards goals in real time.
- Peer reviews. Again these are common practice in the technical community; they are somewhat more acceptable to senior managers, although still not completely satisfying.
- Metrics. Metrics are usually things that are easily countable, like patents and papers; these are usually not at all satisfactory in evaluating the true worth of a technical program or organization. To make matters worse, from time to time, complex schemes have been proposed that take such "measures" and perform arcane algorithmic operations on them that often obscure whatever little meaning they may have originally had.

In an attempt to cope with this long-standing problem, ARL developed its Performance Evaluation Construct, which we believe is a rational and logical approach to answering the questions of how well the lab is performing and the degree of its health. It is a semi-quantitative approach that requires the Director to take a broad view of many different factors, some numeric and some descriptive, and then to personally integrate them into a picture that he can present to a variety of audiences (including stakeholders) in whatever format is appropriate at the moment. There are three values or principal areas of interest to which the Construct responds:

- Relevance. Does the work being performed respond to some bona fide requirement of a customer? That is, does anyone care about the work we are doing?
- Productivity. On any given project, or for the lab as a whole, is progress being made towards some specified goal at an acceptable rate? That is, are we giving the customer some product of use to him in a timely fashion?
- Quality. Is the work being done at a level that could be considered at or beyond the state of the art? That is, is ARL a world-class institution doing world-class work?

Since GPRA requires that results be described in realistic and readily understandable terms, the Construct is clearly tied to the evaluation requirements of the Act. The Construct is built on three pillars: peer review, metrics, and customer feedback. As indicated in figure 7, these techniques respond to the three values above in varying ways.

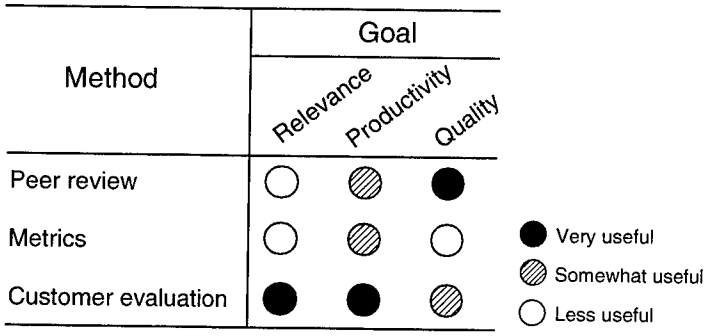


Figure 7. Relationship of three pillars of ARL Performance Evaluation Construct to principal areas of interest.

7.3.1 *Peer Review*

Contemporary or retrospective peer review is a generally accepted approach to performance evaluation throughout the world of science and technology. However, it has certain limitations, such as the breadth, depth, and independence of the reviewers. It specifically addresses quality and, to a more limited extent, productivity; it is not expected to respond to the question of relevance with any specificity. (Prospective peer reviews, often used as tools in grant selection, can respond to relevance if the reviewing body so desires and is appropriately constituted.) A panel of recognized experts in a scientific field is well-equipped to make judgments on the technical quality of the programs and the technical staff, and on the relationship of the facilities and equipment to the state of the art. These kinds of judgments are most important for the leadership of a laboratory if the programs are to be properly executed and the laboratory is to continually improve.

Taking a cue from NIST, ARL contracted with the National Research Council (NRC) of the National Academies of Science and Engineering to assemble an ARL Technical Assessment Board (TAB). The TAB consists of 14 individuals of international reputation. Under this board are six panels of 8 to 10 people each, also of high repute within the technical community. These panels review each of our primary mission areas. The Board, with its panels, provides an appraisal of the scientific and technical efforts of ARL. It is specifically enjoined from making judgments on the programmatic structure of our work, partly because it is not equipped to perform this function, and partly because there are numerous other channels through which ARL receives such guidance.

Because of the size and diversity of the ARL technical program, the panels review the total program in depth over a three-year period, reporting annually to the TAB on the one third of the program reviewed. The panels produce a descriptive assessment in the form of a written report published by the NRC. The TAB also meets annually with the Director to provide an

informal report of its findings before the publication of the report, and to receive guidance on the Director's desires for special areas of emphasis in the next year's review. This meeting is held just before Q2, so that the results of the TAB's review can be used as input to the strategic planning process.

The initial contract with the NRC was for three years at approximately $650K per year. From these funds, the NRC pays the expenses of all the members of the Board and the panels, supplies a full-time Executive Director and appropriate clerical and support staff, and provides for the logistics and publication requirements of the Board. This approach has the advantages of providing the independence and stature required of a peer review, removing any possible conflicts of interest from ARL, and stamping the endeavor with the NRC's imprimatur. The NRC has published its first and second years' findings from the National Academy Press as the 1996 and 1997 *Assessments of the Army Research Laboratory*. Its 1998 review is currently in process.

7.3.2 *Metrics*

The things that are "countable" in the world of R&D, for the most part, are only peripherally connected to the three values of relevance, productivity, and quality. Nevertheless, because of the additional information they can provide (specifically as indicators of the functional health of the organization), metrics are judged to be necessary in any evaluation process. However, they must not be taken out of context nor given more importance than they warrant. For this reason, ARL has eschewed the use of any sort of weighting schemes or algorithmic manipulations of these data. The Director is well qualified to personally integrate the values of the different metrics, and then to report them in whatever format is appropriate for the audience. Overall aggregation into some sort of "score" for the lab is not considerd to be productive.

Accepting these limitations, ARL assembled a set of about 60 metrics for consideration. As might be expected, most of these were input metrics, with several output metrics; metrics for outcomes were, not unexpectedly, absent. These metrics can be aligned with the four elements of the ARL vision statement (see fig. 8). While none of these vision element groupings relate directly to the requirements of GPRA in terms of measuring outcomes, they do provide a useful way to look at information about the health of the lab. Furthermore, viewing these numbers in context can provide critical insights. For example, two of the metrics in the personnel area are number of staff members holding doctorates and the age distribution of the staff. While it is obvious that the first of these would be of concern to a laboratory, age data might seem of more questionable value. Yet, when one ARL directorate plotted doctorates against the age of its workforce, it realized that it had no PhD's on the staff that were under 40 years old. This caused the head of that directorate to re-think his hiring and staff development strategies.

Preeminent in key areas of science ...

Deliverables
- ✔ Top tasks (% met)
- ✔ Science and Technology Objectives (STOs) (% met)

Documentation (leaving tracks)
- ✔ No. of refereed papers/proceedings
- ✔ No. of ARL technical reports:
- No. of chapters/books written
- Patents:
  - Total No.
  - No. of invention disclosures

Facilities/equipment
- $ value capital equipment purchased in FY
- $M invested in facilities in FY
- Replacement rate of facilities

Staff widely recognized as outstanding ...

Profile
- ✔ % PhDs (S&Es)
- No. of technicians per S&E

Training
- % employees with 40+ hr training
- ✔ No. of employees on long-term training
- ✔ No. of employees on academic training
- ✔ Total semester credit-hours completed
- PhD candidates

Esteem factors
- No. of significant awards
- No. of invited presentations
- No. of prestigious posts

Miscellaneous

Financial
- Obligation
- Disbursement
- IH (In-House)/OGA (other Government Agency)/contract $
- ✔ Indirect overhead ($M)
- G&A (% total revenue)

Personnel statistics
- Glidepath
- Average age (S&Es; total)
- Average grade (S&Es; total)
- Average sick leave use (S&Es; total)
- Turnover rate (S&Es; total)

Procurement
- Average small purchase cycle time
- % of Higher Education Institutions (HBCU/MI) contract $
- Administrative/Procurement Lead Times (ALT/PALT)

Seen by Army users as essential to their mission ...

Technology transitions
- No. of significant technology transitions

Ratings from customer surveys
- ✔ Technical Planning Annexes (TPAs)
- ✔ Reimbursable customers
- Users
- Senior leadership

Financial
- ✔ Reimbursable customer orders ($M)

Greening the workforce
- No. of officers
- No. of enlisted
- % employees completing "Greening" course
- No. employees completing FAST (Field Assistance in Science and Technology) Jr. training
- No. of FAST advisers

Intellectual crossroads for the technical community ...

Guest researchers out of ARL
- ✔ Total No.
- ✔ Total work-year equivalents
- Average length of stay
- No. staying 3+ months

Advisers
- No. of NRC approved advisers

Guest researchers into ARL
- ✔ Total No.:
- ✔ No. of post-docs
- No. from HBCU/MI
- ✔ Total work-year equivalents
- Average length of stay
- No. staying 3+ months

Cooperative R&D
- No. of new CRADAs
- No. of new Patent License Agreements (PLAs)
- Income from CRADAs/PLAs
- No. of Technology Project Officers (TPOs)/Assistant TPOs (ATPOs) (international)

Vision element categories

- ✔ Metrics included in Directors' performance standards

Figure 8. FY98 ARL performance metrics grouped by vision elements.

In general, 60 metrics are far, too many to deal with regularly. The data can be collected and used in various formats, but to be useful a more compact set must be defined and then brought to senior management's attention. The Director accordingly decided on 17 that were of special importance to him and that he wished to use as "levers" to move the organization in certain directions and to help set an appropriate environment in which high-quality research could be performed. These 17 were singled out on the basis of the Director's judgment of what a world-class laboratory should look like, a vision developed over a long career of managing R&D organizations (most recently, NIST); these particular metrics were part of that vision. For instance, the Director believes that a world-class research institution should have about 40 percent of its technical staff at the doctorate level. When he came to ARL, he found that this number was at 22 percent. Thus, he included this particular metric among the 17 for special attention.

He then brought senior management's attention to the metrics by including them in their performance appraisals. ARL's senior management comprises the (SES-level) heads of the seven technical directorates and centers who report directly to the ARL Director. The Director negotiates goals for these 17 metrics with the directorate and center heads individually, taking into account the nature of the work in the specific directorate. For instance, a directorate with a mission oriented more towards basic research would be expected to have a higher goal for refereed journal articles and a lower goal for patents, while a more engineering-oriented directorate would have the opposite emphasis. Our Survivability/Lethality Analysis Directorate (SLAD), which concentrates on systems testing for Program Managers, would be expected to have neither papers nor patents in any substantial quantity. Its metrics would include test reports delivered to customers.

In general, the Director sets the goals for the various metrics partly based on his personal experience and partly based on our benchmarkings of other world-class research organizations (see sect. 8).

Although the career of an SES-level manager will not rise or fall solely on whether his directorate makes its quota of patents or papers, placing these metrics in his performance standards does draw his attention to them and has had a noticeable effect on the overall performance of ARL in these selected areas—as was the Director's intention.

At the end of the year, the statistics are gathered and reported to the Director, who takes them into account as he prepares the performance appraisals of his senior managers. These figures are also rolled into an overall ARL picture. The effect of this process is demonstrated by the example of the percentage of doctorates on the technical staff, which has risen from 22 to 27 percent in three years. In light of the various downsizing efforts (hiring restrictions, early retirements, buyouts) that the lab is undergoing, this is real progress towards the long-term goal of 40 percent. Other effects of including metrics from the Director's "short list" in the senior managers' performance appraisals are the following percentage changes since 1993:

- number of guest researchers into ARL—up 48 percent
- number of guest researchers out—up 293 percent
- number of NRC post-doctoral fellows—up 94 percent

- number of refereed journal articles—up 155 percent
- number of technical reports—up 10 percent
- number of employees on long-term training—up 127 percent

Obviously, the long-term outcomes of ARL's programs will stem from its technical accomplishments. While these are usually considered in terms of shorter term intermediate outputs, they are among the more important of the metrics that we can collect. These include a variety of "countables" that are defined differently for the different directorates. However, they all boil down to counting how many of the specific technical goals set at the beginning of the fiscal year were actually accomplished. Keep in mind that the quality and value of these individual goals are not evaluated by the metrics, but rather by the other two pillars of the Construct—peer review and customer feedback. However, the metrics provide a handy scorecard to keep track of how well the head of a directorate is doing in fulfilling his annual obligations.

Many of the other metrics are directed towards ascertaining the technical atmosphere and operational health of the laboratory. An example is a group of metrics called "esteem factors." The assumption is that in a world-class laboratory of over 2100 people, more than half of whom are S&Es, there should be a certain number of fellows of national societies, adjunct professors at prestigious universities, winners of major awards, etc. Appropriate goals for such factors are determined by comparison with other world-class laboratories. While such statistics may not be under the direct control of management, the lack of any such honors among the staff (an extreme example) would certainly be an indication that the scientific atmosphere at the laboratory is somehow lacking and needs attention. Similarly, the various input metrics (fiscal performance, facilities, personnel data) provide indicators of organizational health to the Director.

Those metrics not regularly reported to the Director are tracked as part of normal business procedures (many of them by automated systems) by the various functional managers. They are not surfaced to senior management unless they begin to fall outside some envelope, and it is deemed that some form of executive attention is required.

The linkage between all these metrics and the outcomes of a laboratory's endeavors is certainly tenuous, but no more so than in industry. A great deal of work has been published in this area, much of it summarized in publications by the Industrial Research Institute. This body of work shows that although various metrics can be defined in financial terms, for R&D the collection and reliability of these metrics, and their relationship to the company's profits, are extremely problematic.

7.3.3 *Customer Feedback*

The third pillar of the Construct incorporates the concept of a customer into the research effort. While this focus is certainly familiar in the world of development and production, it is somewhat foreign to the world of research. Nevertheless, if someone is being paid for some work, research or

otherwise, the payer presumably expects a product from the payee. That payer is the customer.

ARL has developed this notion by the use of a model of the "stakeholders" for the research enterprise, developed by Professor Edward B. Roberts at the MIT Sloan School of Management.* According to this model, in industry there are three groups of stakeholders for the research effort: two within the firm and one outside (fig. 9). The most obvious group within the firm is the development and/or manufacturing and/or marketing departments, who depend on the output of the research group for the raw material (ideas and technologies) that will become the basis for new product lines. The external stakeholder is, obviously, the end user or customer of the firm. However, the other internal stakeholder, which might not be as obvious, is the senior leadership of the firm, the Chief Executive, Chief Financial Officer, or Chief Technical Officer, who needs the concepts under investigation now in the research arm of the firm to enable the setting of the long-term strategic vectors for the company.

Translating this model to Army acquisition, we have customers for the immediate short-term products of our efforts: the RDECs and the various system Program Managers and Program Executive Officers (PMs/PEOs). These customers require specific products from the research organizations to fit into their development programs. Like the private sector, ARL also has an ultimate end-item user—the individual soldier in the fighting units. While we may not deliver a research product to this ultimate customer, we must be ever mindful of his real-world needs and requirements as we conduct our research on concepts for systems that might appear on a battlefield 10 or 20 years from now. (Part of maintaining this awareness of the soldier's needs is gained through the ARL "Greening" program, attendance at which is one of the metrics shown in fig. 8.) Finally, again in parallel with industry, we have a senior leadership that must look farther into the future than a PM, for instance, who is concentrating on fielding a system in the next year or two. The Chief of Staff of the Army, for example, must shape the fundamental concepts of our fighting forces for the next several decades. He becomes a stakeholder in the laboratory, since the most advanced technologies being worked on today will shape not only

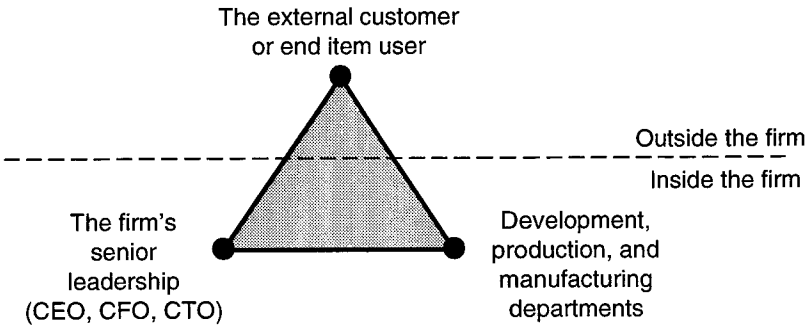


Figure 9. Roberts' model of researcher's stakeholders.

Roberts, Edward B., "Benchmarking the Strategic Management of Technology—II: R&D Performance," International Center for Research on the Management of Technology, MIT Sloan School of Management, working paper 119-95, January 1995.

the systems that appear on the future battlefield, but the combat doctrine and force structure as well.

For that segment of our customers to whom we deliver specific items, we use a series of feedback questionnaires, not unlike what industry uses, to sense the degree of their satisfaction. We have completed four annual cycles of questionnaires to our internal development customers: to the RDECs for whom we do work at no cost, and to other agencies that come to us on a reimbursable basis for specific tasks. These questionnaires are targeted at those individuals in these other organizations who are responsible for specifying the product to be delivered. After the work is finished, each customer is asked to rate our performance on a 1-to-5 scale in terms of the quality, timeliness, utility, etc, of the deliverable. There is also a place for comments. Our Director has established a policy that any rating of less than 3 on any item, or any negative comment, must be responded to personally by the appropriate SES level directorate or center head within one week. Aside from this feedback process itself, the questionnaire scores are also a part of the metrics process and are included as a basis for the senior leaders' performance appraisals. We send out approximately 400 surveys a year and have a response rate of almost 60 percent. Our overall score has risen from 3.9 (out of 5) to 4.3 over the past four years.

We do not use questionnaires on the other two groups of stakeholders—the end users and the senior Army leadership—since we do not deliver a specific identifiable product directly to either of these groups. However, we have established a Stakeholders' Advisory Board (SAB) that brings together, at the three-star level, the Army's senior leadership and user representatives into a forum that enables ARL to receive first-hand guidance and feedback from these other two important segments of our stakeholders. The SAB has held three annual meetings to date.

7.3.4 *Applicability of Evaluation Techniques*

The survey process for customer feedback is more applicable to the applied research that we do—the requirements-driven R&D—than to the more basic, opportunity-driven research. Peer review, on the other hand, is more applicable to our basic research work. Metrics are applicable with varying emphasis, depending on the metric and when it is applied. In other words, the three pillars of the Performance Evaluation Construct are given different weights at different points in the R&D life cycle.

The three pillars of the ARL Performance Evaluation Construct are related in varying ways to the areas of interest for evaluation: quality, relevance, and productivity. Peer review, as realized by the Technical Assessment Board, provides feedback on the quality of the technical program. The Stakeholders' Advisory Board provides feedback on the programmatic and managerial performance of ARL, which applies to relevance and productivity. Our survey process also inquires into relevance and productivity from the standpoint of those customers who receive specific deliverables from us. The surveys apply at the individual project level, the TAB addresses the program level, and the SAB takes a strategic viewpoint.

Although there may be quantitative aspects to all this information, neither it nor our system of metrics is reduced to a single ARL "score." Rather, the information is digested and integrated by our Director for use in a variety of ways. This approach is in consonance with the basic principles of the NPR, which aims to place the responsibility for managing with the senior managers and free them from mindless, bureaucratic rote.

7.4 Issues and Lessons Learned

A major issue presented by the GPRA to many government organizations is the difference in scale between agencies and how the requirements of the Act will be translated to the working-level organizations within agencies. The Act defines the agencies responsible for reporting these various plans as the cabinet-level organizations. Thus, in our case, the reporting agency is the Department of Defense. Depending on how one counts the levels in the chain of command, ARL is 5 to 10 levels below the level where the strategic and performance plans will be drawn up for Congress. Thus, for all practical purposes, ARL will not be very visible in the aggregation of data at the DoD level. Some of the civilian agencies, which are much smaller than DoD, may well have their R&D functions exposed in somewhat more detail at the OMB and Congressional level. It also needs to be recognized that the ways in which the various GPRA processes are implemented at the organizational level are dramatically different from the way they are at the agency level.

Along the way we have gathered other insights into the GPRA and related processes:

1. A new mindset is required, especially in the world of research. Thinking in terms of outcomes rather than inputs or outputs, effectiveness as well as efficiency, and customer satisfaction, is somewhat alien to the R&D business. However, for GPRA these concepts must be understood, translated into workable constructs for the R&D community, and embraced. Training may help, but in some cases a "religious conversion" will be required.

2. Senior management must buy into the process totally. This acceptance cannot be driven from the bottom up, since it is intimately connected with the very heart of an organization's business. If the senior leadership does not embrace this philosophy as part of their planning process, they will fail in their attempts to use planning and measuring techniques as a part of the management of their organizations.

3. Participation in this type of planning and measuring requires a significant investment in personnel, funds, and time. Despite the original protestations of those who testified before Congress for the establishment of the Act, it is very labor intensive at all levels of the organization. ARL dedicates many work-years of effort to this process, and devotes a significant number of full-time permanent positions to the planning and measuring functions. If this effort were being expended solely to satisfy GPRA, it would have met with a great deal of resistance at ARL. However, since we began the planning and measuring efforts independently for reasons of

good business practice, GPRA has not become a major *additional* factor in the cost equation for us. But it should not be forgotten that, however motivated, this kind of management does not come cheap.

One might consider that political or bureaucratic risks are incurred by an organization exposing itself to such in-depth scrutiny through publishing this array of planning and reporting documents. However, even if such scrutiny were not required by statute, ARL believes that any organization that aspires to be world class must be able to withstand, and learn from, critiques by its peers and stakeholders. Otherwise, the entire endeavor is pointless.

As a side note, except for the NRC's role in our peer review system, ARL chose not to use contractors to support this effort, since organizational planning is an inherently governmental function. We felt that no contractor could know as much about our own business as we do. It is also arguable whether we could get the same level of effort from a contractor for much less than we are expending ourselves.

4. A competent corporate information system is essential to managing the performance evaluation process. We have learned this the hard way, since we do not have one at this time, and just doing the metrics work by hand is enormously time-consuming.

5. The application of these techniques to basic research is more difficult than it is to applied research. Both planning and evaluating basic research (i.e., research that is not requirements-directed) is recognized as very difficult. At ARL we have approached the problem by assuming that all work is done for some purpose and for somebody. In basic research, that purpose and person may not be immediately evident. It may be the Director himself, or it may be "second order": an output from some basic research may be an input to some applied research that does have an identifiable application and customer. Nevertheless, if a purpose and a customer can be defined, then the rest of the process follows more or less directly.

6. Metrics are a very contentious issue. In general, good business practice dictates that a half dozen meaningful metrics are all that should be used in the management of an organization. However, in R&D we have concluded that there simply are no meaningful outcome metrics, in the sense that a manufacturing or service company would use them. We did not arrive at this conclusion capriciously. On the contrary, we undertook extensive face-to-face interviews with the senior leadership of many of our leading technology companies. In every case, they could proudly explain their metrics-related management processes in relation to their product development and production operations; when pressed to discuss their research function, however, they all admitted that they had no satisfactory approach, and that they relied heavily on the intuition of their Chief Technical Officers.

   Whenever we discuss our 60 or so metrics, we immediately receive criticism for their quantity and lack of relevance. Therefore, to emphasize again: all these "countables" are used only as indicators of the health of

various functions within the laboratory. They serve only limited purposes, but these purposes are often important in the management of the R&D enterprise:

- Certain of the metrics serve as indicators in narrow functional areas (such as fiscal performance) and never need to be surfaced to the laboratory's leadership unless they begin to move outside some predetermined bounds.
- Certain metrics may be used by the Director as "levers" to move the organization in directions that he feels are necessary (such as the percentage of PhD's in a research organization).
- Finally, certain stakeholders require data that, for reasons that may not be known to us, have significance to them.

  This last purpose is, in a sense, the most difficult to understand, so we just accept it. Again and again, whenever we have reexamined the set of metrics and decided to drop one as being of little value, we will invariably receive a question from a stakeholder concerning that particular number. Therefore, our philosophy is, "If it's countable, we count it!" We just take care to assure that such data are not misused or misinterpreted.

7. Different stakeholders may have widely diverse views on what is important for ARL to accomplish. There are internal and external views, short-term and long-term views, emphasis on purely scientific output versus technical deliverables versus operational (fiscal, personnel, etc) performance, and so on. The Performance Evaluation Construct was designed to provide the Director with the required flexibility to respond across these various interests.

   Finally, this is still work in progress for ARL. We made a major advance in the latest version of our strategic plan by incorporating for the first time strategic *technical* goals, in addition to the more familiar broad management goals usually seen in such plans. In fact, this drastically revised plan was motivated in part by our receiving a new mission assignment from the former Army Chief of Staff: to develop the scientific underpinning for the future digitized battlefield. That led to a whole new structure for our program, and with it, the new FedLab strategic approach to our modus operandi (discussed in sect. 2).

   Still needing improvement is the all-important linkage from strategy to annual performance. While each of the volumes of the business plan is complete, consistent, and well-structured within itself, the natural flow or driving function from one to the other is not always obvious. Also, strategic human resource planning, facilities master planning, etc, are not integrated into the overall strategic plan. In addition, the actual application of the plan is not optimum. Deployment down to the workforce and first-level supervisors is particularly spotty. Therefore, we will be undertaking a senior-level review of the planning process to see what improvements can be implemented.

Our set of metrics must also be continuously reevaluated in terms of their value to the process, their collectability, their amenability to validation, and most importantly, the message they send to the workforce. It has often been observed that "what gets measured, gets done." We need to assure ourselves that we are measuring the right things so that we will do the right things.

With the submission of the *FY96 Annual Review* to OMB, ARL's participation as a GPRA pilot project concluded. Because of the scale question discussed above, the GPRA *per se* may not ultimately have a major impact on ARL's business operation. However, the planning and measuring that constitute the GPRA process are still important to us and will continue, regardless of the specifics of the eventual implementation of the Act. We intend to continue to use these tools and improve upon them, simply because it is "good business" to do so.

8. Benchmarking ARL

In the first of two separate efforts related to the management of ARL, we undertook a benchmarking study to gain a better understanding of the health of our laboratory. The problem was that determining "health" on an absolute basis was difficult to do without having some sort of guidelines or goals. Benchmarking has enabled us to determine such goals by observing the characteristics of the "best in class" among world-class research organizations. We were pleased to discover that in many of the areas examined, ARL compared favorably with its peers.

8.1 Early Efforts at Benchmarking

Benchmarking is not so much a management initiative as it is a process that we felt obliged to undertake in order to better understand our own business. Since there are so few absolutes in running a research organization, peer comparison is one of the few ways to know if we are heading in the right direction. The data from benchmarking also provides a means, in addition to the Director's intuition, of setting goals for certain of the metrics described in the previous section.

We have been undertaking various benchmarking efforts since before ARL was activated. However, in the sense that I am using the word, benchmarking is not the formal multistep process taught in business schools. Rather it is merely a simple comparison of various attributes of our organization with the same attributes of organizations widely recognized as "world class" or "best in class," the goal being to see how we stack up to our peers, and whether there are obvious soft spots that we need to improve.

One of our earlier efforts occurred in 1991 when AMC, our parent command, began a thrust to apply TQM principles to all its functions, including R&D. The predecessor organization to ARL, LABCOM (Laboratory Command), was given the responsibility to devise the appropriate "technology generation processes" for all of AMC. In the process of doing that, we contacted the following organizations to benchmark their approaches to managing their corporate research functions:

- Bell Labs (on-site visit)
- Corning Glass (on-site visit)
- Motorola
- Westinghouse
- Martin Marietta (on-site visit)
- United Technologies

Concerning the application of TQM methodologies to the management of the corporate laboratories, we learned that these industry leaders employed a variety of techniques in their development, production, marketing, and support functions. However, when pressed specifically about applying TQM to their research functions, every one, without exception, said that they did not know how to do that, and for the most part, they

relied on the intuition of their technical managers. (This was very satisfying to hear, in a perverse sort of way.)

More recent efforts in benchmarking have been to gather data from a variety of peer organizations concerning management processes and output measures. These organizations have included

- NIST,
- Naval Research Laboratory (NRL),
- Hughes Research Laboratory,
- RCA Sarnoff Labs, and
- Lawrence Livermore National Laboratory.

We also made several extended trips to the United Kingdom to benchmark a wide variety of processes against the Defence Evaluation and Research Agency (DERA), the UK's Ministry of Defence corporate laboratory.

Our functional support organizations have been very active in benchmarking their activities with the private sector. We also have worked with the Industrial Research Institute (IRI), a trade association representing 85 percent of the commercial R&D conducted in this country; the Federal Research Assessment Network (FRAN), run out of the National Science Foundation; and an ad hoc R&D roundtable made up of representatives of R&D organizations from throughout the federal government.

Finally, during FY95 we contracted with CHI Research, Inc., to perform an in-depth analysis of our patent output and citation activity in comparison with 14 government, industry, and university laboratories.* These included NRL, Los Alamos, Livermore, Oak Ridge, NIST, JPL, SRI, Bell Labs, Stanford, MIT, Xerox PARC, IBM, and two foreign labs—Julich and Toyota. The summary conclusions were as follows:

- ARL has the most patents per active inventor; i.e., ARL inventors are more productive than their counterparts.
- However, because of the more specialized nature of the government work (especially such ARL work as armor and armaments), ARL's patents are cited far less than those of its commercial counterparts.
- In numbers of patents, ARL is comparable to NRL and ahead of the other government labs, but it is much weaker in its indicators of citation and linkage to nonpatent references (journal articles, which indicate how close to, or far from, leading-edge science its patents are).
- In several specific categories, however, ARL is a leader; those categories are, not surprisingly, related to ordnance and armor materials.

A similar study was also done by CHI on our journal article portfolio,† this time comparing us to seven other government labs, five universities, and five industrial labs. The conclusions of this study are summarized below:

Anthony Breitzman, Margaret Cheney, and John Perko, "Assessment of ARL Patent Portfolio," Final Report, CHI Research, Inc., Haddon Heights, NJ, 28 December 1994.

†*Anthony Breitzman, "Assessment of ARL Literature Portfolio," Final Report, CHI Research, Inc., Hadden Heights, NJ, 25 September 1995.*

- ARL's publishing activity has been steadily increasing over the past five years.
- ARL ranks very high in both papers and patents per million dollars of budget (see the discussion of the results figures in the next section) compared to the other labs.
- Overall, ARL's papers are not as highly cited as would be preferred, but in certain core areas of research, ARL's citations are quite impressive.

8.2 Recent Results

Most recently, we have just completed a survey of the following 15 organizations which, in one way or another, represent first-rate corporate or central research organizations, not unlike what ARL purports to be for the Army:

- NRL
- Air Force Rome Lab
- Air Force Wright Lab
- Air Force Phillips Lab
- Air Force Armstrong Lab
- Lincoln Laboratories
- NIST
- NASA Goddard Space Flight Center
- NASA Langley Research Center
- Agricultural Research Service Beltsville Research Facility
- Bell Labs
- SRI, Sarnoff Labs
- IBM, Watson Labs
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory

We gathered data on their workforce population, their financial situation, and their technical output. We combined this with data from the National Science Foundation,* which yielded a national perspective, and with the 1995 annual IRI survey of its member organizations.† Figures 10 through 17 display some of the results.

Figure 10 shows that strictly by virtue of size of workforce, ARL compares most directly with Phillips Lab, Lincoln Labs, Wright Lab, IBM Watson Lab, NIST, NASA Goddard, and NRL. Sarnoff, Rome, and Armstrong clearly are smaller, while Los Alamos, Livermore, and the Agricultural Research Service labs are a quantum larger.

Figure 11 bears out our Director's view that a world-class research organization should have about 40 percent of its technical staff at the doctoral level. Of the labs surveyed, ARL is fifth from the lowest in percentage of PhD's, and is significantly below both NRL and NIST, the two labs most often compared to ARL. Both of these have about 50 percent PhD's.

National Science Board, "Science and Engineering Indicators—1996," National Science Foundation, Washington, DC.

†Industrial Research Institute, "IRI/CIMS Annual R&D Survey—FY92–95," Washington, DC.*

Figure 10. Size of laboratory: total personnel.

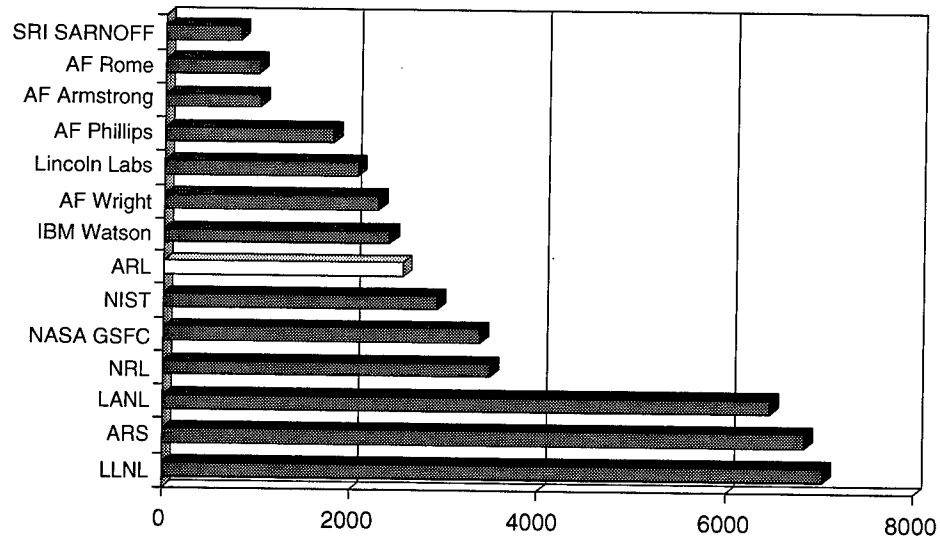


Figure 11. Percentage of S&E staff with PhD degrees.

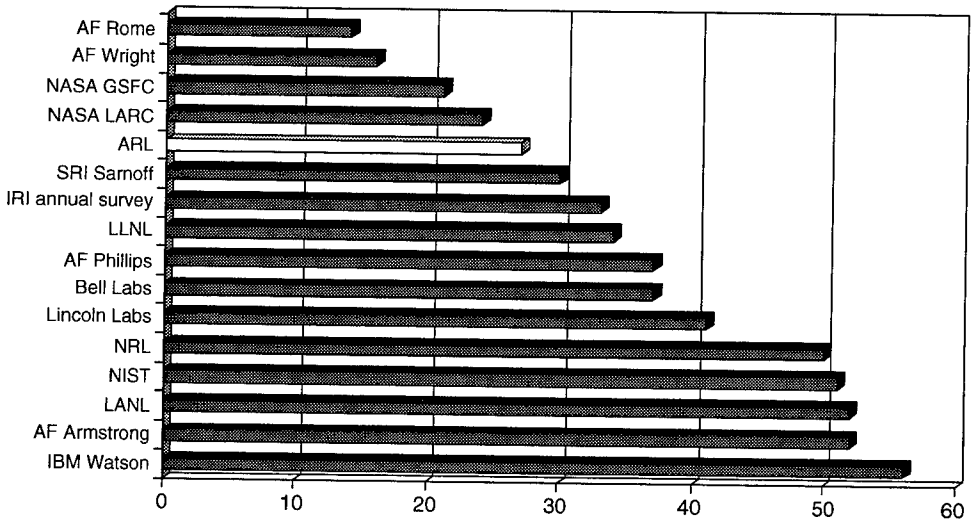


Figure 12 relates to the next section's discussion of overhead. This figure shows the percentage of S&Es in the total workforce. This is what the military might call the "tooth to tail ratio." Here ARL compares quite favorably, having a percentage greater than 56 percent. The NSF book tells us that the comparable figure for R&D throughout the whole federal workforce is only 15 percent, and for the total national scientific workforce, it is just under 30 percent. (However, the annual IRI survey of its members gives a figure of 74 percent.)

Figures 13 to 16 compare the "output efficiency" of these organizations, in terms of papers and patent awards per S&E and per R&D dollar (in millions). For patents, ARL again compares quite favorably (except for the anomalously high number of patents per S&E for the IBM Watson lab; when this number was rechecked with IBM, the answer was "We put a lot of emphasis on patenting"). ARL also seems to be fairly efficient in producing refereed papers for the money invested, although it is not as productive per person as we might like.

Figure 12. Percentage of S&Es in total workforce: tooth to tail ratio.

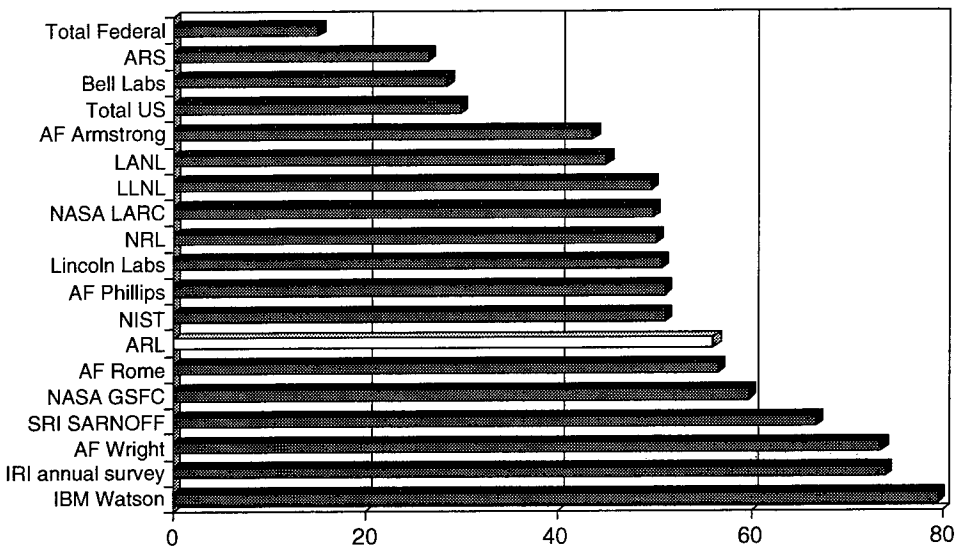


Figure 13. Number of patents per R&D dollar ($M).

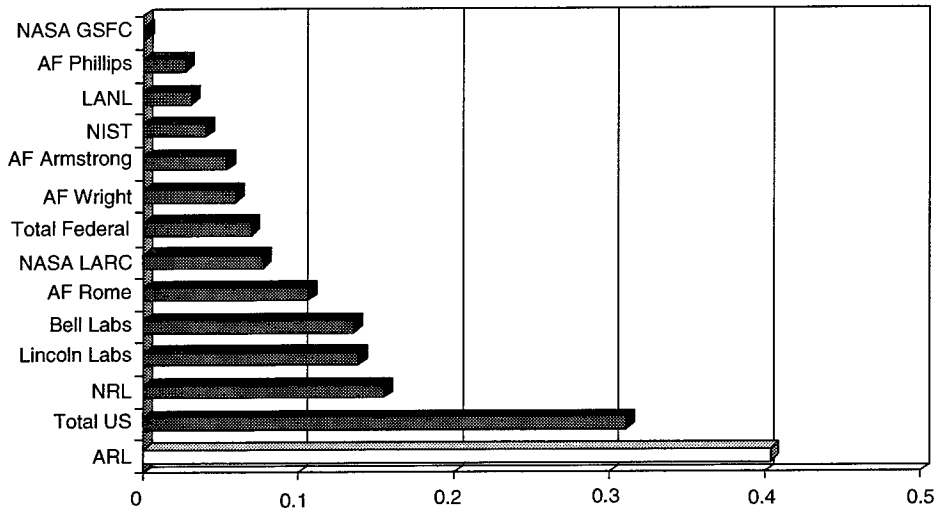


Figure 14. Number of patents per S&E.

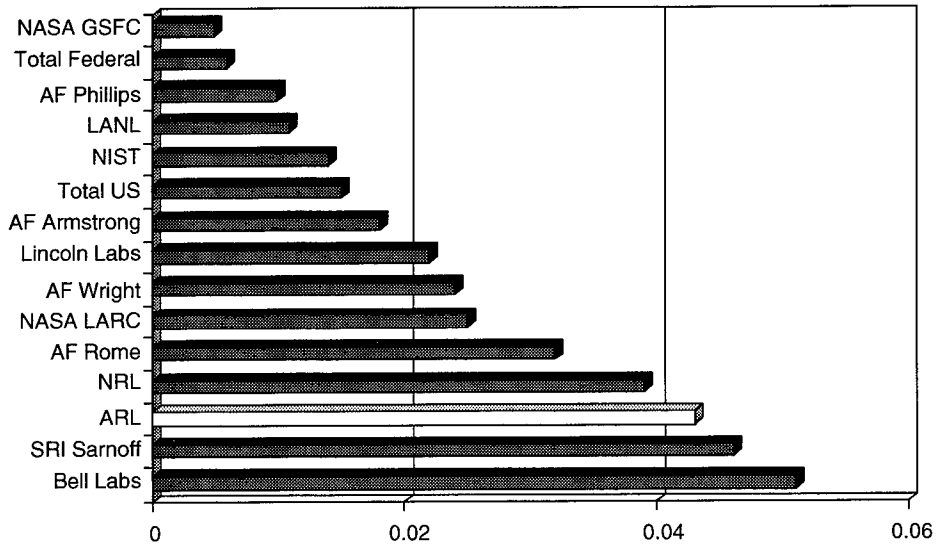


Figure 15. Number of refereed papers per R&D dollar ($M).

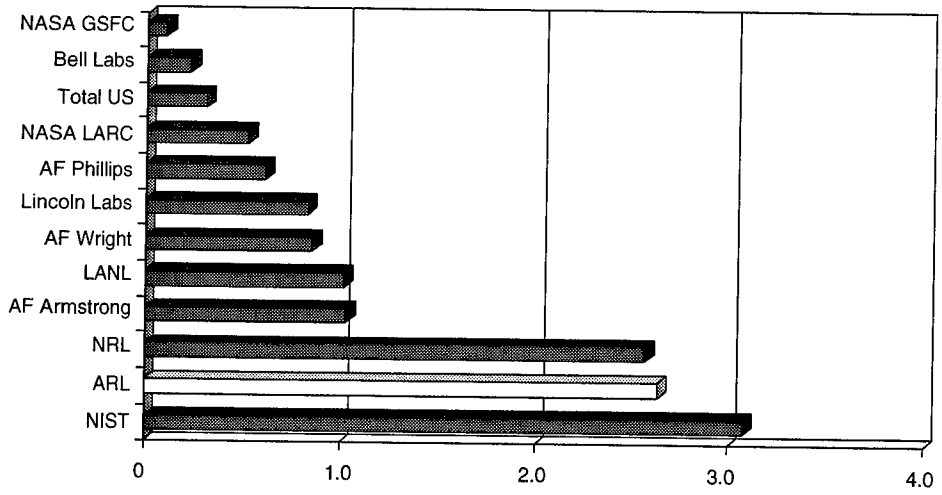


Figure 16. Number of refereed papers per S&E.

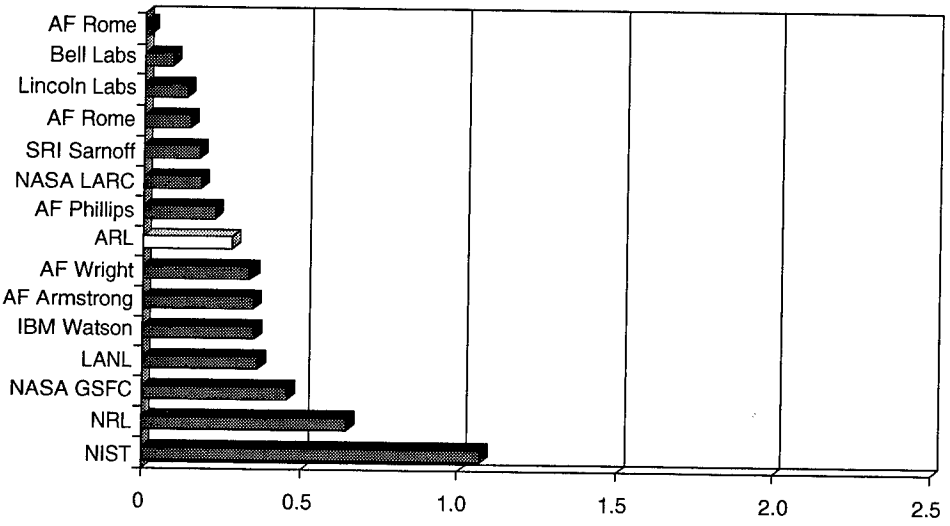


Figure 17. Average salary per S&E ($K).

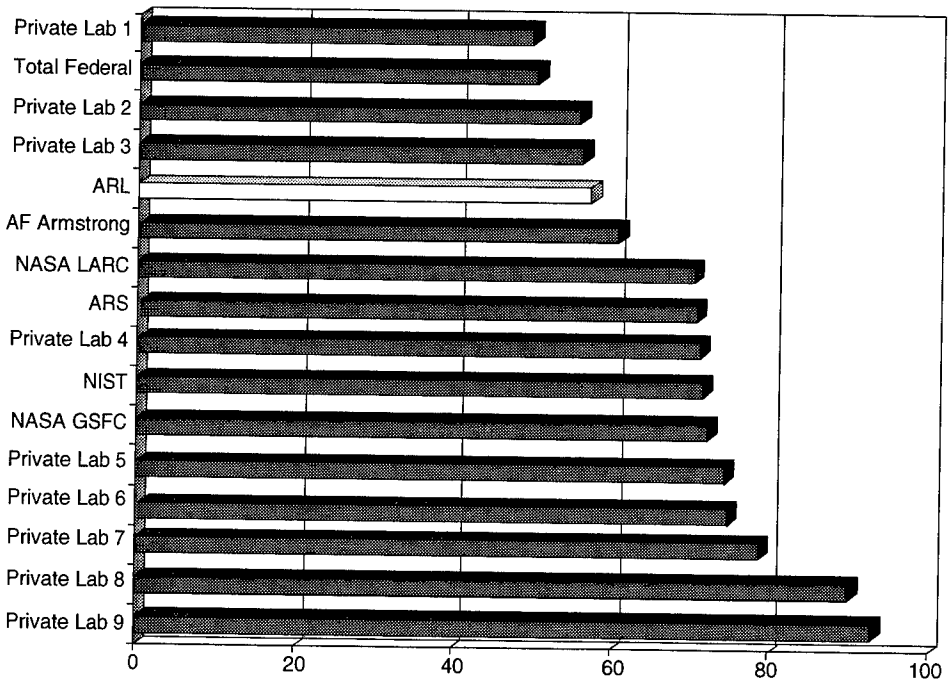


Figure 17 shows the average salary paid per S&E. Again, this is an indicator of how generous ARL is in promoting its S&Es. Of those organizations that would volunteer this particular data point (this was an especially sensitive piece of information for the private sector labs), ARL was clearly on the low side, at $56K, and was only slightly higher than the overall federal average of $50.1K. Five of the private sector labs (who requested that their identities not be revealed) pay their S&Es, on average, over $75K.

One other type of data that was collected (but not plotted because of definitional problems) dealt with the investment that a parent organization invests in its corporate laboratory. The metric is R&D investment as a percentage of sales. For a government lab, "sales" was defined to be the total obligational authority of the agency, since this is somewhat comparable to the amount of revenue taken in from Congress as the "customer." In the NSF book's listing of R&D as a percentage of sales for a large number of technology firms, we find numbers running from 10 percent down to 2 and 3 percent. The total industry average is 3.1 percent, the total federal average is 6.8 percent, and the DoD average is 3.2 percent. Several of the labs specifically benchmarked against in this study were also in the 3 to 6 percent range. ARL's figure is only 0.6 percent!

All these data, including the CHI reports discussed earlier, need to be studied in more depth. They provide clear indications, in a general sense of where ARL stands in relation to its peers in a variety of areas. Some of these indications demonstrate weaknesses that need attention. However, of greater significance to our stakeholders is the fact that ARL is indeed doing more with less, and in some cases, a lot more with a lot less.

9. Overhead Study

A second study effort related to the management of ARL was undertaken because of the importance of controlling overhead costs; since these are not well understood, their management is highly problematic. Besides gaining knowledge about the subject, we were pleasantly surprised to discover that, compared to other well-known research organizations, both public and private, ARL compares very favorably, keeping its overhead rates relatively low.

9.1 The Overhead Problem

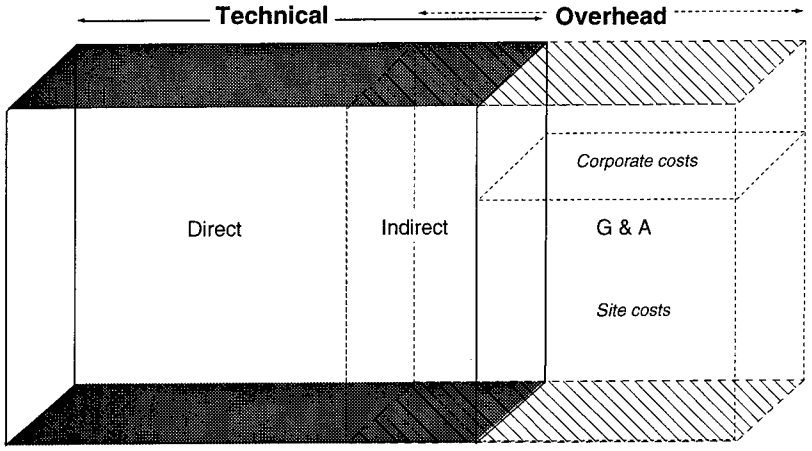
Overhead is one of the most vexing problems for R&D organizations: what it is, and how it is defined, accounted for, and most importantly, kept under control.

9.1.1 The Problem of Allocating Expenses

Fundamentally, overhead is that collection of expenses that cannot be legitimately charged to a specific project. An engineer working at the bench on a project incurs direct costs for his salary, his equipment and supplies, and any contracts he might award in support of his work. All charges of the organization beyond that are, in one sense or another, overhead. These overhead charges are themselves of several types. The engineer's supervisor (e.g., branch chief) and support staff (such as the branch secretary and possibly some branch technicians) are billed as indirect overhead. These people support the mission work of the technical personnel, but since they provide general support to several different projects, they are not considered a direct charge to any one project. Other members of the organization perform functions that support the entire corporate enterprise, but have no direct relationship to any specific project or group of projects. These functions, the General and Administrative (G&A) overhead, comprise such diverse items as corporate management, facilities upkeep, all the support functions (budget, legal, procurement, logistics, etc), and even the writing of reports such as this one.

An additional complication arises at organizations like ARL that have multiple sites. Certain of the G&A costs are applicable to the corporation as a whole, while others are specific to one site only. For instance, the expense of tending the grounds at the Adelphi site is charged to a different account from that for tending the grounds at the Aberdeen site. Thus, for the sake of accuracy and fairness in billing, we have had to divide our G&A accounts into corporate and site G&A. This division leads to one last twist, which serves to increase the difficulty in accounting for our overhead. While we are the "landlord" at our Adelphi site and, therefore, responsible for all the expenses at that site, we are tenants at all our other sites. Therefore, we are billed for the services we receive from our hosts. We are billed at different rates for the same services at different sites (including the rates that we charge ourselves at Adelphi), and in some cases, certain services at certain sites are provided free of charge. This whole system of overhead allocation is summarized in figure 18.

Figure 18. Types of overhead costs in relation to mission (technical) costs.



9.1.2 *The Problem of Defining Terms*

How are we to calculate overhead: in terms of cost per work-year, or as a cost percentage of funding? If the former, is it the total cost per direct work-year or only the in-house costs per direct work-year? Or should the denominator be total work-years? Complicating these definitions further is the fact that a portion of our G&A expenses, roughly 50 percent, is paid for by a direct appropriation into our mission funds. So should this be counted or not when calculating total overhead "burden" on a direct labor hour? Depending on how the word "overhead" is defined, its value can vary by a factor of three or more.

Benchmarking overhead costs against similar organizations does not help either, because when it comes to overhead, no organizations are "similar." Definitions are different, host/tenant relationships are different, business and accounting practices are different, etc.

9.2 Overhead Investigations

9.2.1 *Associate Director's Study*

In July 1994, our Associate Director conducted a detailed study of the exact constituents of ARL's overhead expense; obviously, to control and reduce that expense, we first had to understand what it was and where it came from. This was also a political necessity, since stakeholders are quick to point the finger at overhead rates, even if they do not know precisely what they are pointing at.

As part of the 1994 study we did some comparisons with NIST, NRL, and the Air Force's Phillips Lab—three organizations that could be considered peers of ARL. Depending on which parameter was compared and how it was defined, ARL came out at the bottom, in the middle, and at the top in terms of overhead costs.

The conclusions of the Associate Director's study were that overhead is extraordinarily complex, there are many different ways to define and

express it, ARL is more or less comparable to similar organizations in its rate of overhead expenses, and there are unquestionably opportunities to reduce overhead everywhere. Clearly, trying to "level the playing field" in order to truly understand overhead expenses and compare them across similar organizations is a daunting task.

9.2.2 *GUIRR Study*

Several years ago, a "scandal" arose involving the overhead rates charged by a university to a large corporation procuring its services. This led to a debate about who was more "efficient" (i.e., had the lowest overhead rate) in performing R&D—academia or industry. In 1992, as claims flew back and forth, the Government-University-Industry Research Roundtable (GUIRR) of the National Academies of Research and Engineering decided to perform a study to settle the question, and, as a service to the R&D community, to shed some light on this difficult problem. A group of seven major research universities and six technology corporations agreed to devise a common template for expressing their research costs (fig. 19), and then to complete the data in the template for comparison among themselves. The accounting firm of Arthur Anderson & Co. agreed to work on a *pro bono* basis to collect and analyze the data so that anonymity could be maintained to protect the proprietary aspects of the information.

After ARL completed the extensive in-house study described above (sect. 9.2.1), the GUIRR study came to our attention, and in December 1994, we offered to participate as a federal laboratory test bed for the template, heretofore only intended to be used on academic and industrial labs. We were accepted into the study in March 1995 as the first of what ultimately were 13 federal laboratories in the study, and made our submission on the template for FY94 data. We took special care to include all our expenses, including the self-charged costs at Adelphi, the host-charged costs where we are tenants, and the value of the "free" services we received at other installations to the best that we could estimate it.

Government-University-Industry Research Roundtabie 04/03/95
Total Cost of Research Template
Government Lab/University/Industry Name: _____
Financial Data For Year Ended: _____

RESEARCH COST OF LABS/ACADEMIC RESEARCH UNITS

(FOR UNIVERSITIES, REFLECT TOTAL ALLOCATED INDIRECT COSTS)

	(A) Research Lab/Dept Direct Cost	(B) Research Lab/Dept Support Cost	Total	Percent of Total
RESEARCH LAB/ACADEMIC DEPT COST OF RESEARCH				
Salary and Fringe Benefits:				
Scientist Faculty/Postdoc	(A1) _____	(B1) _____	_____	_____
Staff: Technical/Clerical	(A2) _____	(B2) _____	_____	_____
Students: Graduate/Undergraduate	(A3) _____	(B3) _____	_____	_____
Other _____	(A4) _____	(B4) _____	_____	_____
Total Salaries and Fringe Benefits	$ _____	$ _____	$ _____	%
Equipment Purchases on Contracts/Grants	(A5) - - - - -	N/A	_____	_____
Other Direct Costs	(A6) - - - - -	(B5) - - - - -	_____	_____
TOTAL COST OF RESEARCH AT THE RESEARCH SITE/FACILITY/UNIT	$ _____	$ _____	$ _____	%
COST OF MAINTENANCE AND USE OF RESEARCH FACILITIES PLUS LIBRARY:				
Operations and Maintenance:	(C)			
Security			- - - - -	- - - - -
Safety/Risk Mgmt/Hazard Waste			- - - - -	- - - - -
Physical Plant			- - - - -	- - - - -
Maintenance			- - - - -	- - - - -
Grounds			- - - - -	- - - - -
Janitorial			- - - - -	- - - - -
Facilities Planning			- - - - -	- - - - -
Other _____			- - - - -	- - - - -
Total Operations & Maintenance			$ _____	%
Utilities:	(D)			
Electrical			- - - - -	- - - - -
Fossil Fuels			- - - - -	- - - - -
Water & Sewer			- - - - -	- - - - -
Other Utilities			- - - - -	- - - - -
Total Utilities			$ _____	%
Interest on Major Construction			(E) $ _____	%
Facility/Equipment Depreciation OR Use Allowance			(F) $ _____	%
Library			(G) $ _____	%
COST OF MAINTENANCE AND USE OF RESEARCH FACILITIES PLUS LIBRARY			$ _____	%
CENTRAL SERVICES/HOME OFFICE COSTS ALLOCATED TO RESEARCH UNIT/FACILITY:				
General Administration:	(H)			
Finance/Personnel/Business Svcs			- - - - -	- - - - -
Legal Costs			- - - - -	- - - - -
Academic Executive Admin/Provost			- - - - -	- - - - -
Medical Center Executive Admin			- - - - -	- - - - -
Computer Systems			- - - - -	- - - - -
Other _____			- - - - -	- - - - -
Total General Administration			$ _____	%
Sponsored Programs Administration:	(I)			
Proposal/Budget Mgmt			- - - - -	- - - - -
Post-award Finance			- - - - -	- - - - -
Other _____			- - - - -	- - - - -
Total Sponsored Projects Administration			$ _____	%
Student Svcs			(J) $ _____	%
Other _____			(K) $ _____	%
CENTRAL SERVICES/HOME OFFICE COSTS			$ _____	%
TOTAL COST OF RESEARCH			$	100%

Figure 19. Form used for GUIRR overhead study.

9.2.3 *Results of Study*

The GUIRR study was published as an Arthur Anderson report in March 1996.* The final list of 33 participants included 12 additional federal labs:

Academia (7)
Indiana University
MIT
UCLA
University of Pennsylvania
University of Southern California
Vanderbilt University
Washington University

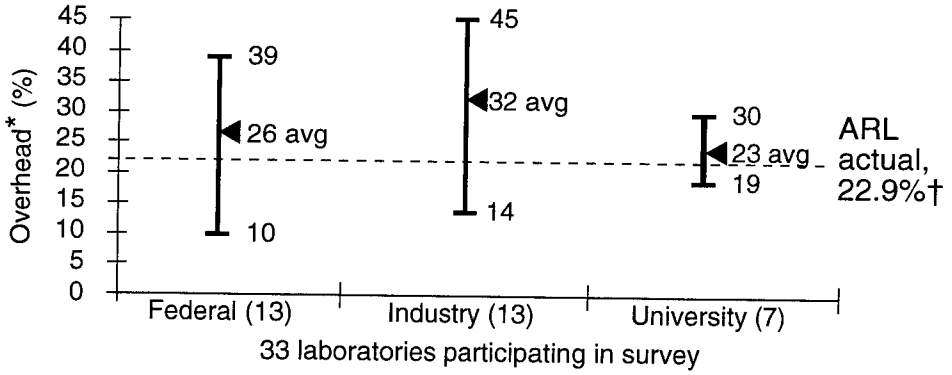
Industry (13)
AT&T
Corning
General Electric
General Motors
Hewlett-Packard
Phillips Electronics
Abbott Laboratories
Bristol-Myers Squibb
G.D. Searle
Genentech
Monsanto Corporate Research
Proctor & Gamble
Upjohn

Federal government (13)
Argonne Laboratories (DOE)
Pacific Northwest National Laboratory (DOE)
Brookhaven National Laboratory (DOE)
John A. Volpe National Transportation Systems Center (DOT)
Lawrence Berkeley National Laboratory (DOE)
Lawrence Livermore National Laboratory (DOE)
Los Alamos National Laboratory (DOE)
National Institute of Standards and Technology (DOC)
National Institutes of Health (HHS)
Oak Ridge National Laboratory (DOE)
Sandia National Laboratory (DOE)
SRI International (a not-for-profit organization)
U.S. Army Research Laboratory (DoD)

The results were surprising. For example, on average, the ratio of direct charges to overhead (indirect and G&A) was remarkably similar for all three sectors—roughly two-thirds to one-third, with the federal sector sitting between industry (slightly lower) and academia (slightly higher). This seems to indicate that, in general, "a lab is a lab is a lab."

We were pleased to see that ARL fared very well in comparison with the other 32 participants. As figure 20 shows, in comparing the G&A portion of the overhead costs, ARL came out below the average for all three sectors.

Figure 20. Comparison of overhead rates by sector.



*Portion of total costs attributable to facilities and G&A/corporate expenses (FY94)
†Includes value of services provided at no cost to ARL

*James H. Roth, "The Costs of Research: Examining Patterns of Expenditures Across Research Sectors," Arthur Anderson and Co. for the Government-University-Industry Research Roundtable, Chicago, IL, 11 March 1996.

9.3 Some Additional Thoughts

"Overhead" seems to have a negative connotation. However, overhead is neither good nor bad; it is simply a cost of doing business. This cost, like all costs, should be kept within reasonable bounds. "Reasonable" is hard to define, since there are no absolute guidelines, and comparisons with other organizations are, as we have seen, fraught with difficulties. Leveling the playing field is extremely difficult, though the GUIRR study took a big step towards doing that. There are still problems, which the Roundtable is considering pursuing in a follow-on study. These include the varying overhead demands of different kinds of technologies (pharmaceuticals versus semiconductors, for example) and the fact that government labs do not use standard depreciation procedures in accounting for their expenses.

Finally, reducing overhead to zero is definitely *not* a goal to be striven for. In that extreme, there would be no support staff, so that S&Es would be left to photocopy their own papers, procure their own supplies, mow their own lawns, and mop their own floors, leaving them very little time to perform their primary job: research. Rather, the goal should be to keep overhead at a "reasonable" rate, by using such techniques as BPR (see sect. 5) to deliver these support services in the most efficient and cost-effective manner.

10. Discussion: Quality and Survival

Following these discussions of the various management initiatives that we have undertaken and the status of each, it is appropriate to take a step back and consider certain aspects of the "big picture." One would expect that quality would be a major contributor to the success of any organization, research or otherwise. Based on this assumption, ARL has undertaken a number of quality initiatives, described briefly below. However, much to our chagrin, it has been our experience that quality alone is not sufficient to assure survival. In fact, ARL has been deeply involved in a great deal of activity over the last several months in dealing with the survival problem that faces most, if not all, research organizations, both in and out of government. Some of the aspects of this problem have been summarized from a variety of documents and our own experience over many years, and these are presented below.

10.1 TQM

10.1.1 The Quality "Journey" at ARL

Over the past several years, as TQM has waxed and waned as one of a long series of management fads, ARL has been caught up (not always willingly) in the fervor. As described in section 8, we engaged in a fairly intensive benchmarking effort with some of the R&D world's corporate leaders to understand how they used (or did not use) TQM techniques in managing their corporate research arms. We tried some experiential learning, and some multifunctional, self-directed teaming. These have all had some limited success, particularly in the area of the support functions.

In our efforts to implement TQM, we twice applied for the Presidential Quality Award (the federal government's counterpart to the Baldrige Award), as well as applying for a State of Maryland quality award, and annually for the Army R&D Organization of the Year Award. The exercise of applying for awards was seen as a way to test our implementation of TQM and reinforce its principles within the organization—and actually winning an award would further reinforce the use of TQM. However, in general, researchers being fairly iconoclastic people, the sloganeering and "touchy-feelie" aspects of TQM have not met with widespread acceptance. In the midst of our researchers' crushing workload and the continuing struggles to defend ARL's budget, award programs seem to add little value.

Although such programs and processes may be extremely useful for many types of organizations, their value added is more questionable for basic research. Our Director's view is that a high-quality research organization does first-rate, state-of-the-art technical work and keeps its external customers happy, and that the support staff does everything it can to enable the researchers to accomplish this goal. If we are doing good work and fully supporting our customers' needs, then the other benefits of quality programs will follow of their own accord.

10.1.2 *Determining Quality*

How can we know if we are doing good work and satisfying our customers? Based on the performance evaluation techniques described in section 7, we can use the Technical Assessment Board process to determine the technical quality of the work. The customer survey process and the Stakeholders' Advisory Board provide the feedback from our customers.

We have recently looked at going beyond customer satisfaction to "customer value": that is, capturing the hearts of customers to the point that they will not only be satisfied when they receive your product, but they will go out of their way, and even sacrifice time, money, or convenience, to come back to you the next time. (We are all familiar with the phenomenon of finding an auto mechanic that we trust to the point that we will even pay more and drive an extra distance just to have that extra comfort factor.) ARL contracted with the University of Maryland's Center for Quality and Productivity to perform a customer value survey among our principal customers, the RDECs, to see what attributes they would value most from us. The answer, like so much that comes out of the quality arena, was fairly predictable: communicate with the customers; talk to them, listen to them, visit them, keep them informed, involve them in the planning process, etc.

Thus, we view "quality" less as a process or a mechanism (or an opportunity to win awards) than as a mindset that creates an atmosphere pervading all that we do. It is a prerequisite if we hope to survive and be successful in fulfilling our mission.

10.2 Survival: Some Philosophy about "The R&D Problem"

All corporate labs today (and ARL in particular) share a common problem: a failure or inability to communicate to stakeholders (who usually do not have an R&D background) what R&D is all about, why it is important, and how it is done. In ARL's experience, there are several common manifestations of this problem, as follows.

10.2.1 *"Why In House?"*

The argument against an Army corporate lab is often expressed as "Let industry (or the universities) do it. Why do we have to do it in house?" This translates into two questions: why do in-house research in the Army at all, and why have an in-house central, or corporate, laboratory for the Army?

Four general arguments can be made for in-house Army research:

- The "smart buyer" argument. If the Army is to be able to intelligently acquire the complex technological developments for tomorrow's battlefield, it must have a cadre of people that understand both the technology and what the private sector is offering to deliver, and can then evaluate what is delivered to assure that it can do the job. These knowledgeable technology integrators must have a place in which to develop and maintain their expertise in militarily relevant technologies.

- The "niche areas" argument. Certain militarily relevant technologies simply have no counterpart in the private sector (e.g., armored combat vehicles). Therefore, while there are acquisition sources for things like tanks, there is no source of science and technology for future generations of tanks, other than what is available in house.
- The "high risk" argument. Certain types of research are either of high technical risk or involve/require the use of very expensive, very large, and very specialized capital equipment. Industry is usually unwilling to undertake such work or purchase such equipment on its own.
- The need to be close to the user. Because personnel at an in-house Army lab (which include some uniformed personnel) will have a closer relationship with the user (the soldier) than would private sector personnel, they will have a better understanding of the user's needs. This allows the user's requirements and concerns to be more accurately translated into the acquisition process.

Given in-house Army research, then why an Army central laboratory? The reasons are the same as can be put forward for industry corporate labs. According to a study by the Industrial Research Institute,* 90 percent of industrial technology corporations have a corporate or central lab, working either alone or in concert with labs in the business units or product divisions. These organizations have found the following benefits of central labs:

- Efficiency. It would be prohibitively expensive to maintain a critical mass of basic technology expertise in multiple organizations.
- Synergy. Most technical problems require multidisciplinary solutions.
- Perspective. Only a central lab can pursue paradigm-breaking approaches to achieve revolutionary improvements in effectiveness (in ARL's case, battlefield effectiveness).

10.2.2 "Culture Clash" Between Leadership and R&D

The culture of the military leadership who, by and large, have had only minimal (if any) scientific training is significantly different from that of the R&D environment. The leadership tends to have an understandable distrust of a system that continually says, "Send money, have faith. Something good will result in 20 or 30 years, although we're not exactly sure what it will be." Although this is indeed the way R&D usually works (strange as it sounds), it is obviously a difficult argument to make to decision-makers faced with severe cutbacks in the total budget. The problem is how to communicate to the leadership the true worth of R&D and the benefits of investing in it. This problem is compounded by the fact that the fruits of 6.1 and 6.2 work tend not to appear in any obvious way in the final product. Even though the technologies evolved over the past 20 or so

*"*Industrial R&D Organization and Funding Charts," Industrial Research Institute, Inc., Washington, DC, March 1995.*

years have made possible the current generation of (for example) tanks, the ARL logo does not appear anywhere on the M1A2 Abrams tank. To deal with this problem, ARL prepared and distributed a marketing brochure called "ARL Within" (emulating the "Intel inside" advertising campaign). It seeks to reveal the many places where ARL technologies appear in today's fielded systems. However, even this approach risks inspiring the question, "What have you done for me lately?" and brings us back to the problem of the time lag between inputs and outcomes. As described in section 7, there are no metrics to allow a real-time evaluation of a laboratory's performance in terms of outcomes. We faced this as part of our GPRA pilot project by the construction of our Performance Evaluation Construct (sect. 7). Although this has drawn a great deal of interest from all over the government (as other labs struggle with the requirements of GPRA), it still does not do much for our military stakeholders.

Even if the senior leadership is not hostile to an in-house corporate laboratory, if often sends ambiguous or ambivalent signals. For example, during the first meeting of our Stakeholders' Advisory Board, we discussed, among other things, the various "balances" that we are trying to achieve as a research laboratory (between in and out of house work, between mission and customer-funded work, etc). One of the balances discussed was among near-, mid-, and far-term work. We estimated the balance at 45, 34, and 21 percent, respectively. After a short discussion, the consensus was that we were out of balance, and that our far-term work should be 50 percent. Although this is obviously closer to the "right" answer, it flies squarely in the face of the other signals we continually receive from the Pentagon.

10.2.3 The "Bananas" Problem

A currently fashionable suggestion is that the Army has "all the technology it needs" for now. Thus, we could call a moratorium on research for five years and use up what we have now, especially since the Army is not currently procuring any new systems that could use the technology we are developing. At the end of five years, we could check back, see how we're doing, and then, if we need some more technology, start some of these labs up again. Within the military, some people are calling this a "tactical pause."

Aside from the obvious problems of shutting down and later reopening research laboratories, what is often not recognized is that research is much like bananas. If I deliver to you now all the bananas that you need for the next five years, you presumably won't need to invest in any more bananas for that period of time. Then, I'll come by in a few weeks and check on how you and your five years' worth of bananas are doing.

The point is, bananas don't keep; neither does research. Although research results do not actually rot, they become out of date, superseded by other research, or rendered irrelevent by new directions in research. (Furthermore, closing down labs is more like uprooting your banana trees than merely trying to freeze the bananas.)

10.2.4 *The Portfolio Problem*

We are often asked how we know what to work on. The answer is, of course, complex. We basically try to sense the environment. We talk to our customers, both the immediate customers—the developers (to whom we deliver products)—and the ultimate customers (the soldiers), who end up using the products that our immediate customers develop and field. We maintain contact with the larger scientific community to understand the latest technologies being worked on elsewhere; we also perform work that evolves naturally as a result of the path that research lays out in front of us. We have a strategic planning process that sets the major technical vectors for the laboratory. Another approach we have taken was the promulgation of the five Grand Challenges (discussed in sect. 7.2.1), as a means to demonstrate (and actually provide) focus to the lab's efforts.

This approach also seemed to resonate with the military leadership. However, despite our efforts, there is always some uneasiness about why we have chosen to do one piece of work and not another.

10.2.5 *The "Duplication" Illusion*

"Everybody is doing the same thing!" Among senior leaders whose training and career experience is not technical, misunderstandings can arise. After a quick scan of the landscape, they observe that everyone is working on the same problem. They imagine enormous savings from streamlining all this "duplication." An extreme case of this kind of thinking occurred several years ago, when one of these senior leaders was visiting several of the Army's laboratories and observed that there were lasers to be found everywhere. He concluded that we were all duplicating each other's laser research. Certain organizations were subsequently "forbidden" to work with lasers. We tried to explain that all these lasers were laboratory instruments and were being used as tools in other types of research, much as one would use a hammer or a screwdriver. Our argument had no impact; his mind was made up, and he did not wish to be confused by the facts.

10.2.6 *Defending Research*

The five situations described above are some, but by no means all, of the manifestations of the broader problem of how, in an era of downsizing, a corporate laboratory maintains the support of its stakeholders. These problems are not particularly new or unusual. Laboratories in both the public and private sectors have struggled with them for decades without having found any universal solution. ARL has also been engaged in that struggle. We do not claim to have found that solution either, other than to use every bit of creativity we can muster to communicate with our stakeholders, explain who we are and why we are important, market them, persuade them, beg, plead, and cajole. However, it is an unending labor.

11. Conclusion

How are we doing? Have we made any real progress in managing a corporate research laboratory? We think so, but we have a long way to go. Here is the "warts and all" report card as promised at the beginning of this report:

- FedLab. This, the real reinvention of our fundamental mission, has been under way for two and half years, and is looking good. Very exciting technical work is going on at this point. However, the question is whether there will be some real, transitionable output at the end of the five years. Just as with all research programs, we must wait and see. Some rough administrative edges still need smoothing out, but these are not show stoppers. One problem, which is now getting serious attention, is better integration of the work among the partners in each consortium. Grade: A (plus a Hammer Award).

- Open Laboratory. Managing the support structure to facilitate the FedLab initiative, especially the personnel rotation aspect, the Open Laboratory has surfaced lots of problems, but not tackled many. While Open Lab is not absolutely critical for the success of FedLab, without it the working environment will suffer. These are complex administrative and cultural problems for the most part, and will take enormous willpower to fix. Grade: C–.

- Waivers. One part of reinvention is unburdening ourselves from inappropriate, irrelevant, outdated, or just plain silly regulations and policies from higher headquarters. Although it is often discussed as if it were the same as reinvention, getting these waivers is mostly nibbling around the margins of the serious problems facing us. However, we have been able to make some progress in gaining small reliefs here and there, which result in time and process savings in many of the support areas. Several of the waivers, current and planned, are important to enable certain aspects of both FedLab and Open Lab. Although not at all insignificant, it is not the "be all and end all" that it was advertised as. Grade: B.

- Business Process Reengineering (BPR). Similar to the waivers initiative, BPR is also aimed at unburdening ourselves, but this time from self-imposed constraints. A lot of good work was accomplished in analyzing what could be done, and a lot of potential was defined. However, much of the implementation depends on automated information systems that we do not yet have (but which are starting to appear). There is also some cultural resistance already forming about changing the way we deliver some of our support services. Grade: A for preparation, and C for implementation.

- Laboratory Quality Improvement Program (LQIP). The follow-on to Lab Demo, LQIP was to provide the large-scale reliefs that every one of the dozens of blue ribbon panels over the past 30 years have said are necessary for the effective functioning of the DoD laboratories. Despite a few small successes, LQIP was basically stymied at every turn whenever one of the really "hard" problems was raised (such as personnel management or fis-

cal resource management). Grade: At the last major LQIP meeting, the discussion was whether the grade should be a D– or an F.

- Alternative Personnel System Demonstration. The single most important element of all laboratory management reinventions, reforming the personnel system has been called for by panels of experts for decades. Although the most significant features of the proposal were removed by DoD, the program is now up and running. Grade: A (for potential) (plus a Hammer Award).

- GPRA. Under GPRA, we devised new techniques for planning and evaluating R&D.

  - Planning. ARL established a business planning process that goes from strategic plan to annual performance planning and reporting, coupled to the budget cycle. The four-volume business plan itself is well put together and breaks some new ground by including specific strategic technical goals (instead of just the usual "motherhood" statements). However, the linkage between the volumes is not as clear as it should be, and deployment of the overall plan down throughout the workforce has not been accomplished to the extent that it should be. Grade: B.

  - Evaluation. We devised and implemented the three-pillared Performance Evaluation Construct, consisting of peer review, customer feedback, and metrics. The metrics pillar has suffered from the lack of a corporate information system. However, in our opinion this is still the best that anyone has come up with to date, in or out of government. Grade: A+.

- Benchmarking. Benchmarking provides a calibration of where ARL stands compared to its peers. Although not rigorous, nor in depth, the various benchmarking efforts have given clear indications of how well we are doing in certain areas of interest and of where improvements are necessary. Grade: B+.

- Overhead Study. We analyzed exactly what overhead is in terms of a research organization, and identified where and how it can be reduced. The study gave us further insight into managing the lab. Grade: A+.

This is a progress report, not a final report. All the initiatives that have been discussed are still under way, and much work remains to be done. All in all, we believe that ARL has come a long way in tackling the problem of managing research. We compare favorably in many areas with our world-class peers, and in some areas we believe we are the best in class. In other areas, we have much work to do. We have made a great effort to share what we have learned throughout the defense and the federal laboratory community. Managing R&D organizations is an extremely complex undertaking. Thus, we sometimes say that in many of these areas, we are twice as good as anyone else: on a scale of 1 to 10, we are a 2!

We do not believe that we have all the answers. However, we do think that we have figured out what most of the questions are.

12. Epilogue: Outsourcing

As this report goes to press, ARL is about to embark on another major initiative that, along with FedLab, will complete the transformation into the federal R&D organization of the future. Driven by increasing fiscal pressures and by Defense Reform Initiative Directive 20 (DRID-20), we are engaged in an intensive study of the options available to us for outsourcing major functions of the lab. We have formed a project management office and engaged a contractor and a panel of expert advisors to assist us in studying the feasibility of the various outsourcing approaches. These include, among others,

- A-76 commercial activities competition,
- Employee Stock Ownership Programs (ESOPs),
- a Government-Owned Contractor-Operated (GOCO) organization, and
- a variety of other partial or total privatization schemes.

The idea is to take those functions that are considered to be commercial activities (as opposed to those core business activities that constitute inherently governmental functions), and outsource them, either function by function, or as a single entity that will then supply these functions to ARL on some sort of contractual basis. We have been benchmarking as we proceed with other organizations that have done this, both in the government (such as NIH's National Cancer Laboratory and OPM's security investigations unit), and outside (the UK's DERA).

This process raises exceptionally complex issues, not the least of which is how one defines "commercial activity" versus "inherently governmental function." The study is ongoing, so there are no results, or even guesses, as to how it is going to turn out. The only thing that is certain is that some course of action will be taken over the next six months, and that ARL's metamorphosis into a truly world-class research organization with a state-of-the-art management program will be completed over the next year or so.

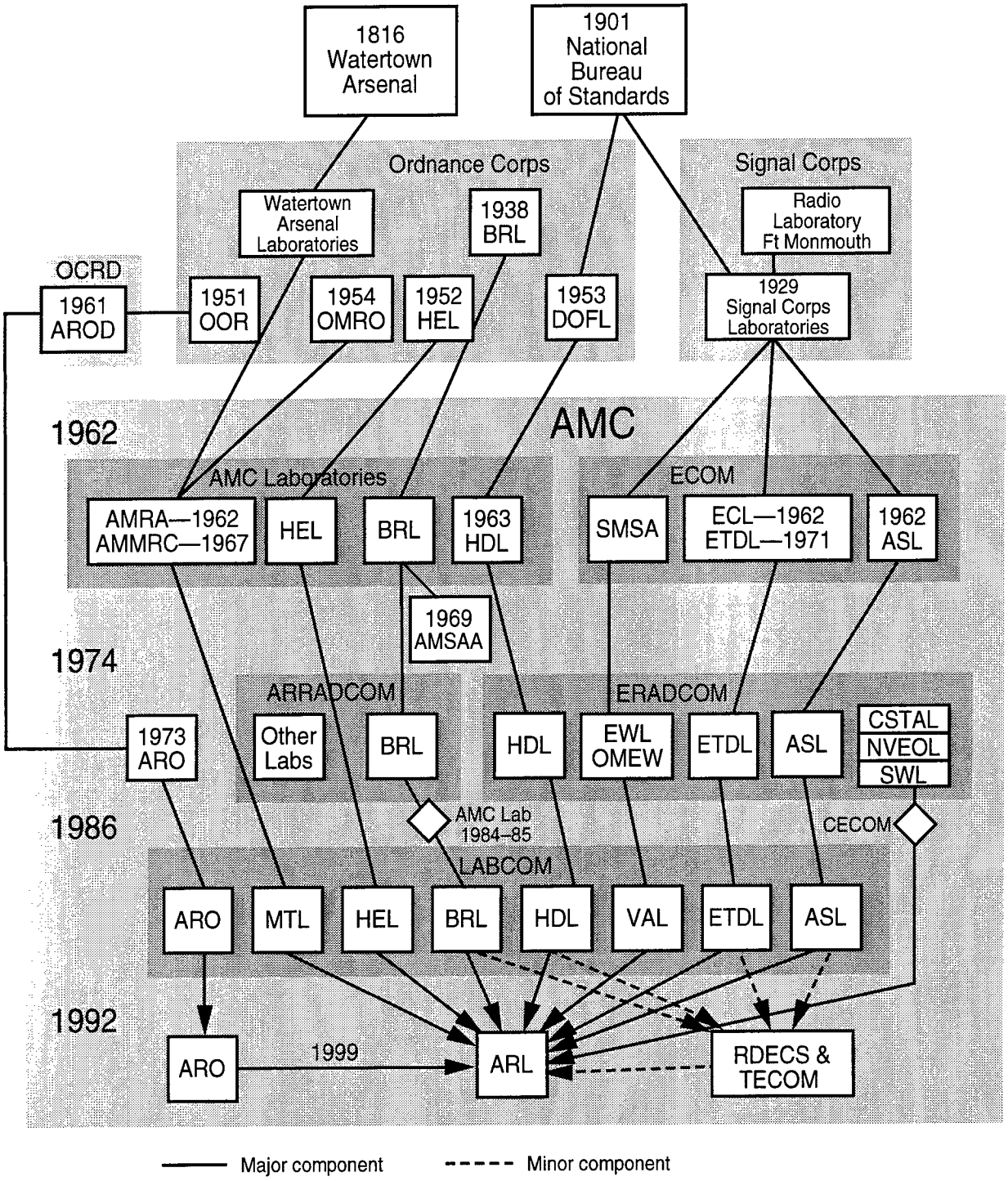
"Plan for change—it happens!"

Acknowledgement

In the quest for better lab management over the years, the author has had close and significant working relationships with many people. Those relationships, in one way or another, have helped to shape the views expressed in this report. In this regard, I wish to thank and acknowledge two people in particular. The first is M. Kiplinger Hine, Jr., the former Director of the HDL Program and Plans Office, and for many years the author's mentor and guide.

The second is Bruce M. Fonoroff, who has been the author's colleague, friend, and "foxhole mate" during almost 30 years of fighting the good fight for a better Defense R&D program. Without the stimulation of innumerable conversations with Bruce, the collaborations with him on literally hundreds of projects, big and small, and working with him to put out the seemingly endless management brush fires, this report could not have been written.

Appendix. ARL Organization Genealogy



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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 1998	Final, 1 October 1992 to Present

4. TITLE AND SUBTITLE
Reinventing Government Research and Development: A Status Report on Management Initiatives and Reinvention Efforts at the Army Research Laboratory

5. FUNDING NUMBERS
PE: M65

6. AUTHOR(S)
Edward A. Brown

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
Attn: AMSRL-SP
2800 Powder Mill Road
Adelphi, MD 20783-1197

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-SR-57

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
2800 Powder Mill Road
Adelphi, MD 20783-1197

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
AMS code: 665898.M65
ARL PR: 8DA6SP

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Army Research Laboratory (ARL) was activated at the beginning of fiscal year 1993. Since then, ARL has operated in an environment of continuing stress, caused by a variety of factors. Like many other "corporate" research laboratories, it has been subject to economic constraints and pressures, leading to downsizing, consolidation, infrastructure reduction, and outsourcing. As a military laboratory, it has also been significantly affected by the end of the Cold War.

To cope with this changing environment, ARL has undertaken a variety of management initiatives: in the current jargon, it has been reinventing itself. This report summarizes the current status of these ongoing initiatives. It begins with a discussion of the fundamental reinvention of the research effort at ARL—the Federated Laboratory—and then discusses several others that directly or indirectly support it. The report concludes with a summary appraisal, in "report card" form, of the reinvention efforts over the past five years.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Federated Laboratory, FedLab, GPRA, NPR, Business Process Reengineering, R&D management, overhead, benchmarking, waivers, TQM, reinvention	91
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102